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ABSTRACT

This paper originated as part of the early phases of internal planning within the National Institute for Education (NIE). A status study was conducted of the existing system of educational research and development (R&D) which (1) provided a framework of information as an initial context for framing policy and (2) examined a major mandate, given to NIE in its creating legislation, to build an effective educational R&D system. Three parallel courses of action were followed to gather information on the status of the R&D system: (1) data collection; (2) development of a larger framework of analysis to guide subsequent work (the present paper); and (3) design of a plan for an administrative unit of NIE charged with monitoring the development of the national R&D system and sponsoring studies related to its operation. The discussion here, centered on the framework development, divides into three major sections. The first section presents a framework of discourse on modelling. A specialized vocabulary is introduced and basic concepts of monitoring are presented. A "bridge" is provided between the simplified discussion of modelling presented here and a number of models not discussed. The second section presents a set of general criteria for tracing boundaries of educational R&D systems and expands the concept of educational R&D beyond usual acceptation. The third section deals with a specific framework for modelling the R&D system and reporting on it that is sufficiently comprehensive to accommodate most current models of R&D and the great majority of data available from either large-scale sampling at the national level or research on portions of the system. A concluding section relates the framework to NIE concerns. Appended is the author's view of how R&D fits into the world of knowledge. (MM)

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MODELLING A NATIONAL EDUCATIONAL R&D SYSTEM: A CONCEPTUAL FRAMEWORK

by Stacy Churchill
Ontario Institute for Studies in Education

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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January 18, 1974

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Foreword

The paper presented here owes much to the assistance and encouragement of numerous persons both at the Ontario Institute for Studies in Education and at the National Institute for Education. At the NIE particular mention should be made of the contributions of Dr. Ward Mason and the assistance of Ms. Nancy Holt and Mr. Donald Fischer.

The content of the paper remains, as the saying goes, the responsibility of the author. It constitutes an attempt by a practising administrator of educational research and development (R&D) to think about the underlying theory of his field of work. The intended public is a very narrow range of persons concerned with the methodology of defining and monitoring R&D systems. The focus is educational R&D, but there are numerous generalizations to other areas, especially where the objective of R&D involves social change.

Given the narrow range of the paper's intended public, the author considers the following to be its major weaknesses and strengths:

Weaknesses

1. The content of Section I is almost purely didactic, and, there fore, irrelevant for most of the intended audience. Its justification is the possibility that, together with the numerous examples of Section II, the section might assist readers with other interests to assimilate the outlook and content of the more substantive sections of the paper.

2. The examples given in Section II for many concepts are both superfluous and superficial for the informed reader. The reason for their presence has just been stated.
3. The paper provides few footnotes or references. Given the many areas touched upon, the author feels that such additional pedantic apparatus would add nothing for the informed reader and, for the occasional person new to any area, would be of less utility than a few minutes in a reference library.

Strengths

1. The methodological discussion may have some utility for workers in the field who may use it as one point of comparison for their own efforts, for the following reasons:
   (a) The discussion of boundary definition in Section II includes a brief summary of almost all criteria currently used. Obviously these criteria are sometimes mutually contradictory, a reason which explains why they are seldom found discussed in one place. (The author is unaware, doubtless through unfamiliarity with relevant writings, of any other such formulation of alternatives).
   (b) The discussion of "regulators" is probably original in the context of monitoring R&D systems of any kind.
   (c) Extending the concept of educational R&D to task-oriented and informal education and to information processing systems, as done in Section II, is relatively new in the

literature. The discussion of related system boundary criteria is probably original.

2. The proposal for a reporting framework is apparently well grounded in current needs of NIE (and other institutions engaged in educational R&D). The specific framework proposed is certainly not sacrosanct and is subject to restatement and revision. However, the author feels strongly that, whatever framework is used for reporting, its clarity and comprehensiveness as a "bird's eye view" of the whole enterprise should not be any less than that in the proposed framework. Such a framework, once adopted, should be maintained consistently over time as a point of reference in all documents on the R&D system published by NIE. The practical utility of such a procedure is enormous, provided the formulation of the model is in "neutral" terms. This means that it should be acceptable both to the educational "practitioner" and to the R&D "doer". Communication failures are at the heart of many policy failures of the recent past.

3. The model of the R&D infrastructure for education is an adaptation from other fields, though the formulation includes original elements.

4. The proposal for adopting, in addition to other modes of inquiry, an economic perspective for studies of the R&D system is not entirely new, though it is more comprehensive than other existing

proposals and discusses certain methodological problems not previously found in the literature.

The value of these judgements is left to the appreciation of the reader.

Stacy Churchill

MODELLING A NATIONAL EDUCATIONAL R&D SYSTEM

A CONCEPTUAL FRAMEWORK

by Stacy Churchill

Introduction

A. BACKGROUND

This paper originated as part of the early phases of internal planning within the recently created National Institute for Education. The Planning and Policy Analysis Unit identified the need to begin an immediate status study of the existing system of educational research and development which would serve a double purpose: to provide a framework of information as an initial context for framing policy recommendations and to begin examination of a major mandate given to NIE in the legislation which created it:

> "... to build an effective educational research and development system." (Education Amendments of 1972, Title III, Sec. 405. (a) (2), p. 99).

Information on the status of the R&D system was necessary, therefore, as a guide to formation of policy on developing it and, over the longer term, as a measure of the effectiveness of those policies. Three parallel courses of action were chosen:

a) doing a rapid survey of existing statistical sources, mainly secondary, to document recent trends; given the need to act rapidly, the data collection framework was patterned after the major previous study, Educational Research and Development in the United States, prepared in 1969 by the National Center for Educational Research and Development (NCERD 1969);

b) developing a larger framework of analysis to guide subsequent work (the present paper being a first step in this task); and

c) designing a plan for a permanent administrative unit of NIE charged with monitoring on a permanent basis the development of the national educational R&D system and sponsoring studies related to its operation.

A survey of the current literature on educational research and development in the United States reveals that almost all studies have been undertaken to serve purposes narrower than those laid down in the legislative mandate for NIE. None seemed to be comprehensive enough to serve as a long-term planning and research framework; indeed, it was clear that no single model or model type would suffice for the purpose. It would be necessary to create successive models to determine their power as instruments of research and explication, selecting certain elements from some as a basis for the long-term monitoring function of the proposed administrative unit. The present paper fits within this context. It is a tentative start at providing a framework of discourse within which numerous models might be proposed. It should go without saying (but doesn't) that this is not the only framework of discourse which may be employed; others are invited to add their own frameworks: a national system of research and development is a concept which, in our society, has such breadth and complexity that its ramifications defy the imagination, much less the ability of systems theoreticians to codify it.

A further caveat is necessary: this framework is the slave of its purpose, just as the systems proposed by others serve their designs. The purpose here is speculative, to expand the horizon of most existing models proposed for the educational R&D system. It is not intended as a guide to short-term action. More specifically, if the discussion raises areas of a potential "R D system" which are a bit far-fetched and unrelated to present public policy concerns, this is not intended to suggest that they should be policy concerns. There is no implication that such "new" areas are, should be, or ever will be, the object of any federal program. Nor is it proposed that they be included in an NIE monitoring system. Though there are potentially many policy applications of the framework, we are now dealing with speculation, not programs for action.

B. MONITORING AS A FUNCTION OF NIE

Since 1953 the National Science Foundation has carried out regular annual surveys of research and development activities in the United States (cf. NSF 1971, 1972). Its numerous reports and publications are at the basis of almost all the work which has been done on an international level to develop a system of international comparisons (Lefer 1971). Given this situation, the question immediately arises: what is the role of NIE in monitoring the component of the R&D system that deals with education? The straightforward answer is that the NIE should do monitoring which is closely related to its mandate but, wherever possible, by taking advantage of NSF work and avoiding duplication of it. Let us defer discussion of the NSF data collection framework until later and concentrate on the needs of the NIE.

The creation of a monitoring system would be of great assistance in assessing the success of the NIE in carrying out the portion of its mandate, mentioned earlier, concerned with building "an effective educational research and development system." But the information provided by the monitoring system would be of potential utility for all aspects of NIE operations. Generally speaking, the following functions can be assisted by a monitoring system:

1) External communication and public accountability: Regular reports on the status of the R&D system can be a vehicle to communicate about the whole range of NIE policy interventions and their impact. The cumulative effect of such reports over a period of months and years will be to provide baseline data and a yardstick to measure the effectiveness of the NIE. Reporting about, and research on, the R&D system will have a tendency in the long term to shape national conceptions of what R&D is and what education is.

2) Internal policy making: A monitoring system should assist in policy making by providing advance indication of problems that require policy initiatives for their solution. In general, the

problems will either result from an imbalance or maladjustment within areas currently covered by policy initiatives or from the appearance of new factors outside the focus of current policy concerns; this suggests that monitoring will be most intense as regards current areas of policy intervention but that the system would also keep track of events in a broader context on a more distant basis. In summary, the first function is problem identification.

The second function is to assist in weighing policy alternatives, supplying data on (a) the context of decision-making and (b) the predictable impact of policy alternatives. The third function, closely related to the first, is to provide feedback on the consequences of policy initiatives.

3) Research on the system: The advancement of knowledge on the operation of the educational R&D system is a valid subject for scientific enquiry. The advancement of such research being within the purview of the NIE's mission, it follows that it is worthy of attention in its own right, independently of the fact that explication of causal relationships within the system can be of crucial importance for effective policy making.

C. APPROACH

The discussion that follows is divided into three major sections. The first section is intended to acquaint the general reader with a framework of discourse on modelling. A specialized vocabulary is presented and basic concepts of monitoring are presented in terms which, it is hoped, will be generally accessible to most readers but sufficiently precise that the professional systems analyst will have no difficulty in "translating" them into his usual terminology. (The reader with previous experience with the jargon of systems analysis will probably wish to skim through most of this material to determine the degree of simplification used and the exact context of familiar terms). Since a complete discussion of the literature relevant to the modelling of educational R&D systems is beyond the scope of this paper, a "bridge" has been provided in the last part of the first section, in which a number of familiar models are discussed using the terminology and concepts just defined. The second section is a discussion of modes of tracing boundaries for the educational R&D system. Numerous definitions of R&D and of R&D systems have been given in the literature. This section does not attempt to pick one of them or propose a new one; rather, a set of general criteria for tracing systems boundaries are explicated and the concept of an educational R&D system is expanded well beyond the usual acceptation. For specific monitoring tasks, the criteria can eventually be applied and used to include or exclude parts of what is called in this section an "extended" concept of the educational R&D system. The third section deals with a specific framework for modelling the educational R&D system and reporting on it. The purpose is to present a broad framework sufficiently comprehensive to accommodate most current models of R&D and the great majority of data available from either large-scale sampling at the national level or research on portions of the system. The author apologizes in advance for the shortcomings of this hazardous attempt to provide a framework capable of integrating and interrelating meaningfully data that is derived from numerous sources using different methodologies of research. A concluding section relates the framework to immediate NIE concerns.

One final caution is necessary. Given the general aims of this paper, it would not be appropriate to use the terms R&D or research and development in a "correct" and therefore restrictive sense. Unless otherwise specified, these terms are used in a colloquial sense to refer to the whole spectrum extending from basic research through applied research to development and implementation of innovations. This imprecision is a necessary correlate of an attempt to discuss diverging views of the R&D process, some of which are extremely broad.

Section 1. A Framework of Discourse on Modelling

A. PURPOSE

The purpose of this section is to acquaint the reader with a framework of discourse which will be used in the remainder of the paper. An attempt has been made to provide a framework capable of being readily understood at the intuitive level, yet sufficiently clear that, in specific applications of the framework, precise definitions can be given. The framework is presented in two parts: a short "vocabulary" and a definition of the concept of monitoring in so-called "systems" terms. This is based upon an adaptation of usual terminology employed in descriptive analysis of systems. In other words, nothing really startling or "new" is being proposed.

The utility of the framework of discourse should be tested against the following criteria:

1. Intuitive understandability for the non-trained user.
2. Generality sufficient to accomodate differing viewpoints on the system being analyzed (including different viewpoints about what should be the system boundary, of which more later).
3. As a specific criterion derived from criterion (2), ability to accommodate a major portion of current "models" of R&D,either as regards model content or the context of model definition. In other words, one should be able to map many existing models into the framework without distorting them; similarly the framework should permit the description of the processes by which the models themselves were formulated.
4. Utility for persons engaged in a variety of tasks:
   - generating research ideas
   - reporting research findings
   - reporting long-term changes in the systems under study, i.e. social bookkeeping activities.
   - discussing and formulating policy alternatives.

A summary of these criteria is to state that the framework is a tool whose worth should be judged by its applications.

B. LANGUAGE CONVENTIONS

1. Models

In ordinary discourse among systems analysts (whether or not this is their job title), a "model" is a formalized description. The object of the model may be some part of perceived reality (a chair, how checks are processed at a bank, how change occurs in a school) or a state of the describer's imagination (a proposal for a new policy, a utopia of a deschooled society, a poem). Our discussion will center around models descriptive of something (still undefined) called a "national R&D system", including the process by which its goals are formulated and by which alternative definitions of the system are proposed and developed. For the purposes of our discussion, models will ordinarily consist of:

a. A definition of system "elements"

b. A statement of relationships between elements.

2. Element types

Most of the purposes of this paper will be served by proceeding as informally as possible, leaving the reader to formulate intuitive impressions of some items rather than forcing him to digest complex abstractions. The series of terms defined below are the classes of items which can become system "elements". In applying them to a definite model, one will give them further, formal definitions and specify relationships according to the aims of the model builder. The definitions given here can be "mapped" into the formal definitions and the usual terminology of systems analysis with little effort. In many applications of models, the degree of formality in describing and categorizing elements can be left rather low, as the actual observation of the elements will involve some rough approximation where fineness of definition is lost.

The proposed list of terms is as follows:

1. agent: One or more persons concerned with any phase of the R&D enterprise:

One determines the level of "aggregation" according to utility for the phenomenon studied, e.g. the university department might be a useful level for studying some aspects of financial support for R&D,

the researcher (or perhaps the research team) might be an appropriate unit for studying creativity in basic research, the local community for studying changes in expectations regarding in-school discipline.

2. regulators: Procedural conventions, determining the activity of agents: the most easily defined regulators are those derived from statutory law (e.g., legislative mandates for funding R&D, laws or regulations governing the adoption of textbooks); formal policy codes of public institutions are also accessible; de facto behavior patterns of, say, education administrators faced with decisions on adoption of innovations, may be as crucial as the foregoing but are far harder to document and describe. Personally perceived, or administratively prescribed, role definitions as well as value systems of individual agents or classes of agents, are "regulators."

3. flows: Any (input/output) variable affected successively by two or more agents of the system. The variables are chosen according to their utility for analysis.

4. events: Interactions between any system elements (agent-agent, agent-flow, etc.).

5. pools: A handy catch-all for system elements whose behavior is difficult to predict because they break out of the system "boundary" (i.e. what the analyst chooses to see or study) and return at undetermined intervals: "manpower pool", "knowledge pool," etc.

6. medium)
7. message) : These two elements refer to the classic distinction between message content and its physical encoding. The definition of each is left at the intuitive stage in this paper. The reader is reminded that the term "medium" does not refer to the equipment or physical installations associated with delivering messages, e.g. broadcast studios for television, which would be called "equipment".

8. equipment:	Physical devices or installations (laboratory apparatus, physical plant, etc.)
9. indicator:	Any system element from the above set of elements which is observed in the real world as an indicator of how the system, or a part of it, is operating.

It should now be clear that some of the system elements overlap: "messages" might be one type of "flow" studied at a given time. The point about these cases of overlap is that they are easy to recognize and deal with when applying the terms to specific examples.

3. Remarks on application criteria

There is no general rule for selecting elements for inclusion in a study, other than the general criterion of usefulness for the job at hand, whatever that may be. Anything in the universe is potentially related to anything else. "System boundary" is the technician's term for indicating the point at which the analyst feels it is expedient to stop analyzing and describing relationships. With regard to the study of the national educational research and development system at NIE, it is necessary to point out that there are clearly two different (though closely related) types of work to be done:

a) Social bookkeeping or long-term monitoring:
There is a need to know how the R&D system evolves over a a long period of time. This provides a sort of over-all benchmark for R&D on a nationwide basis.

b) Explicating: One should like to advance the state of knowledge about how an R&D system works, explicating causal relationships. Some results may be of general interest only, others may help to shape policy-making or to re-shape the long-term task of monitoring the national system.

The criteria for selecting the elements and relationships to include in a system model for study are very different, depending on the task to be fulfilled. The social bookkeeping task is of value only when carried on over a period of time, using similar (or the same) categories of flows and agents for study repeatedly. In short, a prime criterion for selection is durability over time: Ph.D. training programs in educational psychology have existed for many years and are likely to continue in existence for years to come; they might well be sampled regularly as an indicator of a given type of opportunity for research training. Unfortunately, durability is hard to predict, and durable variables do not always have much explanatory value for getting at causal relationships. Simply knowing the numbers of graduates from doctoral programs in educational psychology would not go very far to explain, for example, why the proportion of graduates entering research careers might rise or fall over a decade.

The search for causal relationships leads to selection of agents or flows for study according to their perceived impact on the process under study. Such studies are generally (though not always) concerned with flows related to a restricted set of "agents", e.g. the development-dissemination-adoption process of a regional laboratory during a five-year period could be studied in terms of the elaboration and diffusion of a given set of innovation prototypes originating in the laboratory. Questions regarding national policy or the general effectiveness of the R&D system would require different approaches: either (1) cross-sectional aggregation (almost always by straight summing) of data, such as numbers of agents (researchers, research institutions, etc.), at one or more time periods or (2) longitudinal analyses of flows through numerous agents of the system relating a given output to a given input (e.g. an econometric model relating funding variations to system outputs such as number of Ph.D's granted in social sciences).

C. CONTROL SYSTEMS, MONITORING SYSTEMS AND INDICATORS: AN INTRODUCTION

1. Monitoring as part of a control system

It is possible to conceive of monitoring as a passive, experiential process. The act of observation does not imply participation. We all can look at a street scene from a distance as dispassionate observers. But for the purposes of this paper, monitoring should be placed in a different context, that of policy-making. Monitoring can be seen to have a different, more active sense; observation is the prelude to action. To understand this other sense, it is necessary to begin with a simplified concept of what is implied by policy-making;

this simplified model can then be generalized to cover the whole range of situations involved in a monitoring system of national scope.

Governmental policy-making is essentially aimed at creating some outward effect, at modifying a portion of the legal, political, social or economic environment. For the analyst, this means that it can be viewed as a mechanism for exercising "control" over the environment, a perspective which offers the possibility of fitting it against a relatively uncomplicated model of a control system. Using block diagrams, we can visualize a simple control system as follows:

Insert Figure 1 about here

If this hypothetical system is further analysed, it can be converted to the classic format of a "feedback" loop:

Insert Figure 2 about here

From this diagram it is possible to abstract the essential elements of a control system:

(1) The object system, a defined system whose activities are the object of the control process.

(2) A procedure for gathering data on the status of the system.

(3) A procedure for analysis of data gathered, primarily by comparison with some set of norms or criteria (this may be a comparison with the immediately previous state of the system, a means of determining "trend").

(4) A decision-making process by which alternative possibilities for initiating controlling actions are weighed and a selection is made.

(5) An implementation process by which the course of action chosen is carried out, that is, a control mechanism per se.

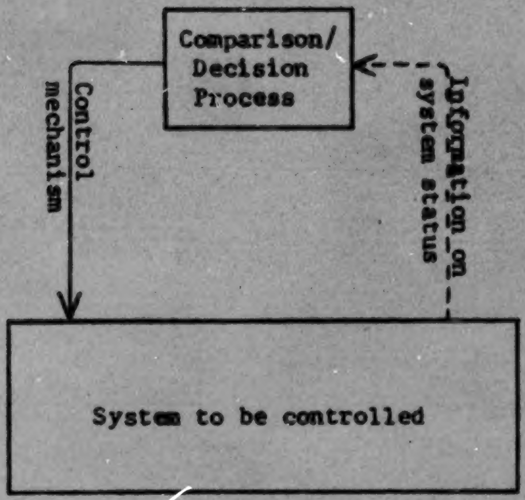
Comparison/
Decision
Process
Control
mechanism
Information on
system status
System to be controlled

Figure 1. Schema of a simple control system

{----- = Information flow}

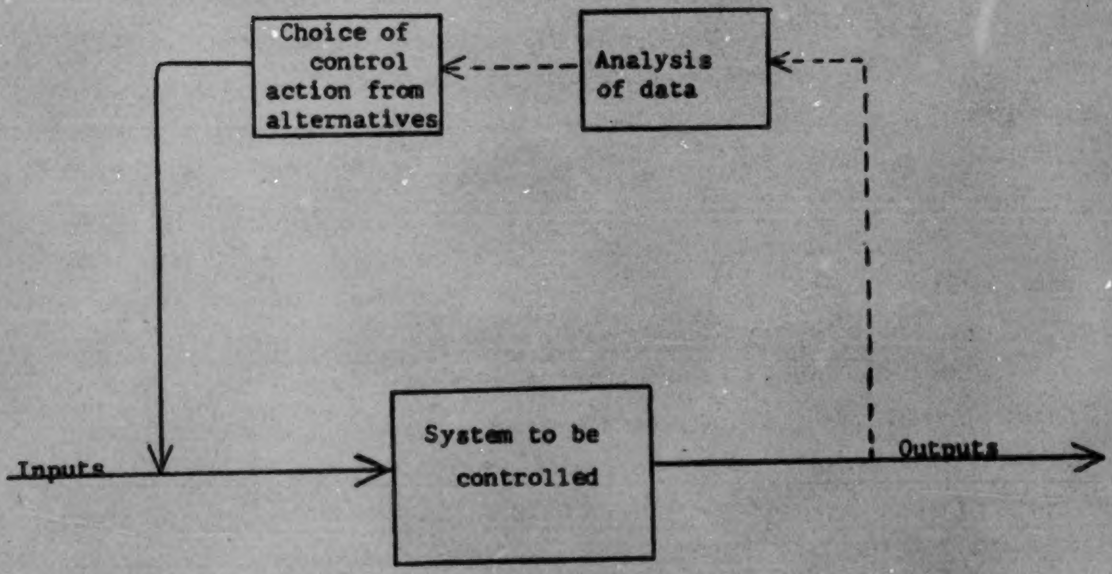
Choice of control action from alternatives
Analysis of data
System to be controlled
Inputs
Outputs

Figure 2.

From the point of view of this paper, monitoring can be defined as elements (2) and (3). In practice, however, an administrative unit responsible for monitoring would ordinarily participate in the process by which alternative possibilities for action are weighed, though properly speaking this is decision-making, not monitoring.

Before proceeding any farther, a methodological aside is necessary to clarify the applicability of this model of a control system. The term control is used in everyday speech to imply total control: "Jones controls the city hall machine" is a sentence implying that what Jones says, is what the machine does. In the study of large systems it is quite clear that total control, in the sense of colloquial usage, is not possible; with regard to social systems, total control implies totalitarianism (a form of government which, by the way, has never succeeded in achieving complete control in any situation). The term control is used here in a limited sense to mean the ability to affect to some extent the behavior of the object system. This is obviously the meaning which must be given to the term when dealing with policy-making affecting the conduct of educational R&D.

2. Components of a monitoring system

The major problems associated with creating a monitoring framework for the needs of the NIE arise from the diversity of the system elements to be studied and the corresponding diversity of methodologies which will have to be used. Different kinds of data will be available in an unrelated fashion, ranging from research on communication patterns within innovative schools to the breakdown of expenditures on individual R&D projects in university research centers. More than a problem of compilation, there is a problem of conceptualization. Much of the data will be available from "research", that is, it will be gathered in the light of scientific interests quite apart from immediate NIE policy needs; the researchers involved will not, in most cases, consider that their work fits within the "control system" framework sketched here. Their contributions to the growth of scientific knowledge may usually be justified in abstract terms independently of their eventual utility for policy-making. Conceptually someone will have to fit the pieces together. The first stage in this process will be understanding how data sources relate to an overall concept of a control system, how research findings are indicators of object system performance.

The underlying concept is deceptively simple. If we return to the earlier schema of a control system, we will note that the object system is viewed as having "inputs" and "outputs". This is roughly equivalent to the statement that, if we look at the national R&D system as a whole, it will be possible for analytical purposes to divide it into sub-components which perform some process in response to some stimuli ("inputs") and produce some results ("outputs")* . An illustration might be that one would be interested in discovering the level of financial support (inputs) received by a research laboratory and the nature of the research outputs produced. We would wish to sample the inputs and the outputs perhaps as a means of making policy on future financial support. The process might be diagrammed as follows:

Insert Figure 4 about here

---

* This "input /output" model is not limited to describing situations in which the object system is visualized as operating changes in something that flows "through" it, for example, a factory process in which machines transform raw materials into finished goods on an assembly line. The model is much more general. Logically it can be transposed into what one might call a "time series" format. The object system, which is initially in state A, undergoes a change during a period of time, at the end of which it is in state B (cf. Figure 3). This means that the model is applicable to all types of status or behavioral changes occurring over a period of time, independently of whether the factors occasioning those changes can be identified.

Insert Figure 3 about here

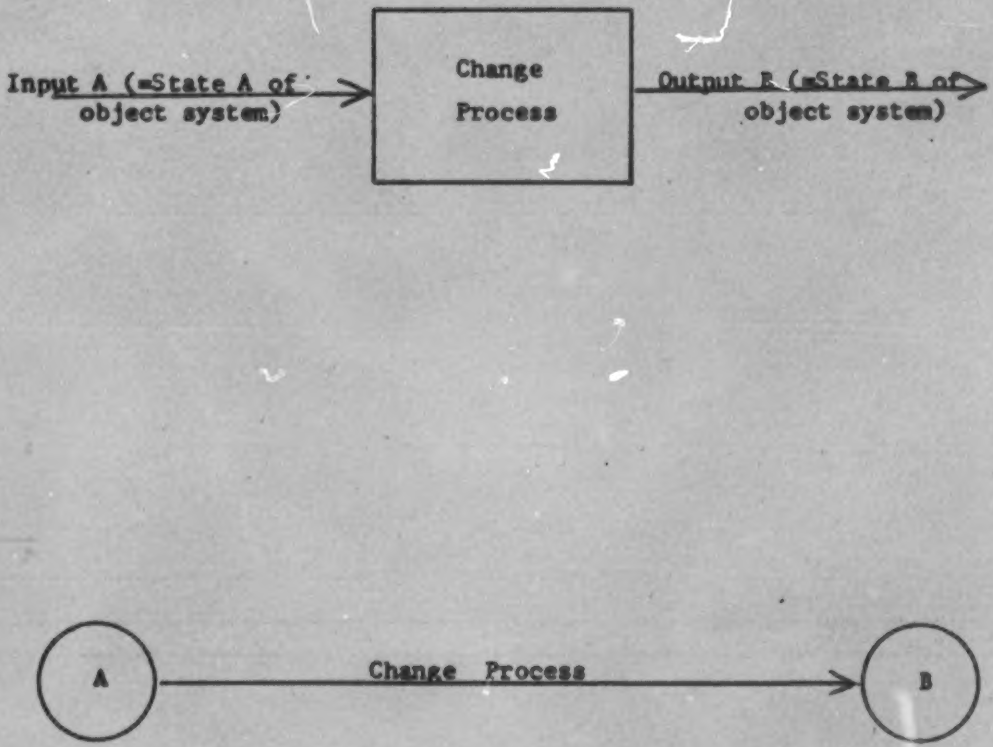
Input A (=State A of object system)
Change Process
Output B (=State B of object system)
A
Change Process
B

Figure 3. Equivalent representations of a process in which the object system is viewed as undergoing a change of state, from state A to state B

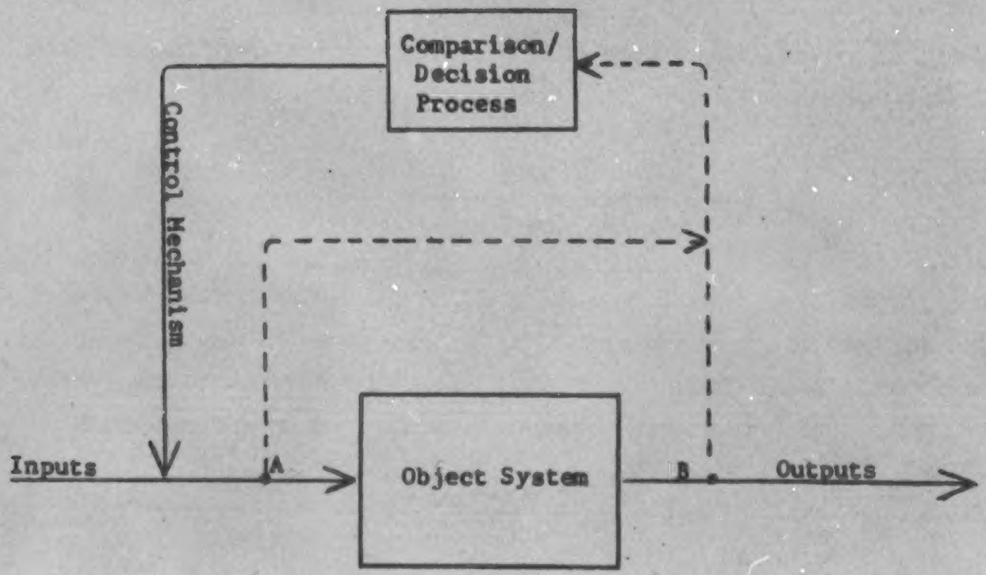
Comparison/
Decision
Process
Control Mechanism
Inputs
A
Object System
B
Outputs

Figure 4.

In the diagram, the laboratory would be the object system, points A and B would be sampling points, i.e. the place in the system where data is gathered. In practice, certain difficulties might arise owing to the delay which separates the beginning of a research activity from the accomplishment of its purpose; if data on financial inputs were available for only one given year, it would be inappropriate to relate those inputs directly to the research results of the year, which probably would depend in a large measure upon investments during previous financial periods. Ideally, one would wish to have, therefore, a record of inputs and outputs over a period of time and, in addition, some indication of research work in progress, as illustrated by point C in Figure 5.

Insert Figure 5 about here

For various purposes, it may be useful to observe the distinction between three types of indicators for any part of the system under study: input, output, activity level (activity in process). With reference to the example, a simple count of projects underway might be considered an indicator of activity level, though admittedly a very poor indicator.

3. Applying the monitoring schema

When dealing with large or complex systems, it is usually necessary to proceed to a sub-analysis in order to define activity level, as illustrated in Figure 6. The introduction of sampling point D

Insert Figure 6 about here

between the two components of the object system corresponds to the identification of an intermediate indicator of system performance. Returning to the example of a research laboratory, it might correspond to the acceptance by a specialized

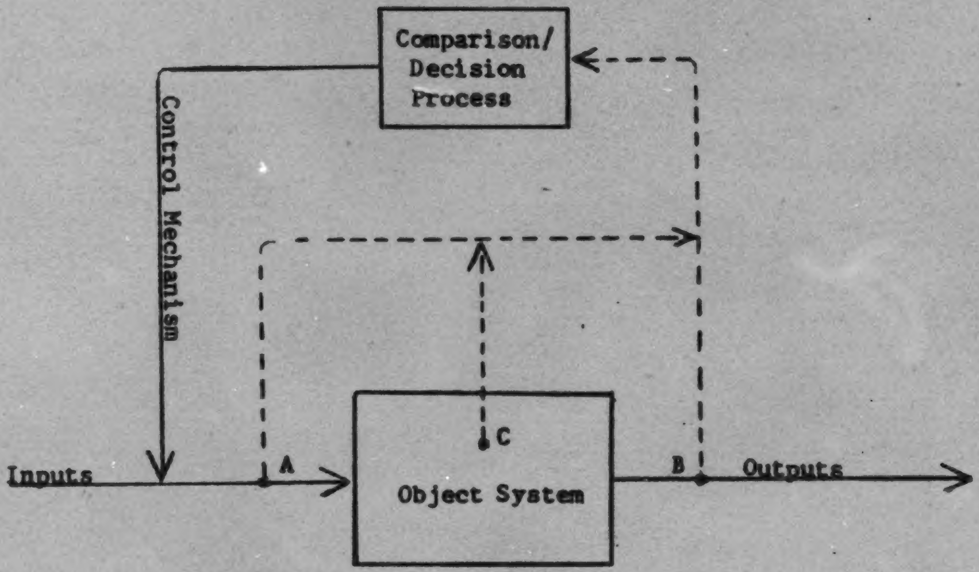
Comparison/
Decision
Process
Control Mechanism
C
Inputs
A
Object System
B
Outputs

Figure 5.

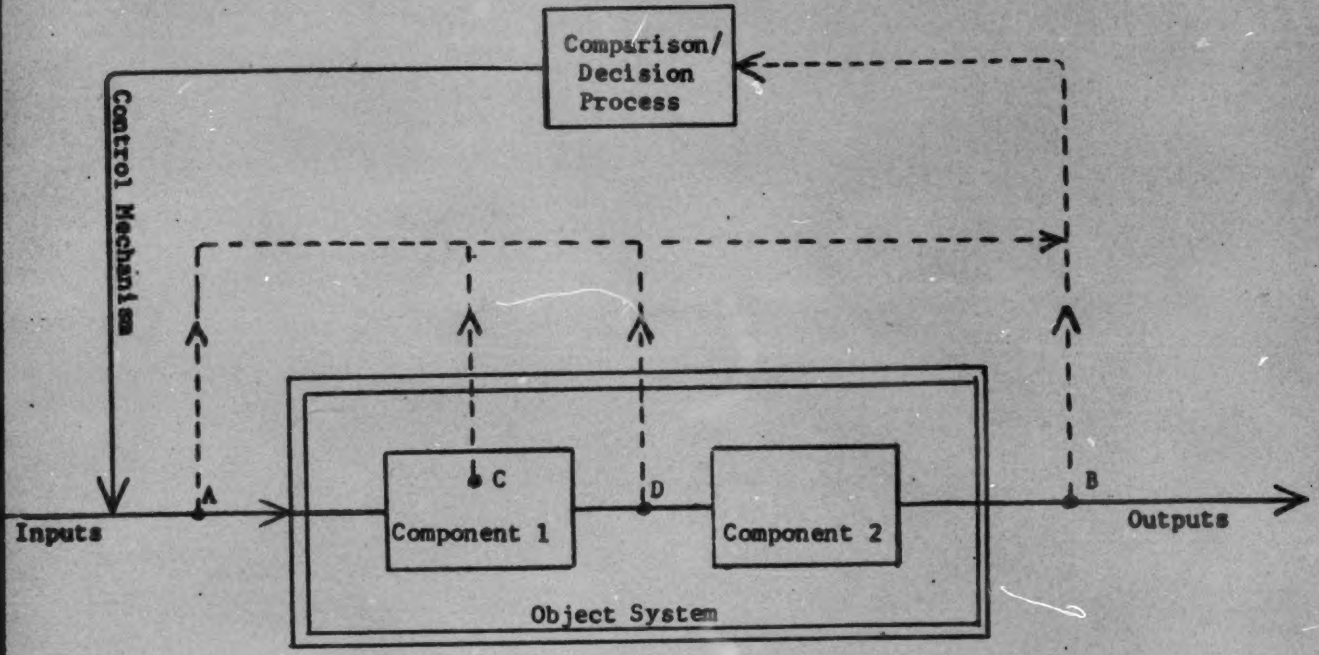
Comparison/
Decision
Process
Control Mechanism
A
C
D
B
Inputs
Component 1
Component 2
Outputs
Object System

Figure 6.

review body of the detailed project design for a given project; completion of this stage might be associated with a high probability of successful completion (during passage through component 2 in the diagram). The use of intermediate indicators of system performance is frequently necessary for one of several reasons:

(a) Process delay is so great between input and output that perturbations in the system will go undetected until so late that no corrective action can be undertaken.

(b) There is such an indirect relationship between inputs and outputs that prediction of outputs is virtually impossible from input data alone.

(c) There may be no adequate means of determining total system output, so that one must be content with summing intermediate outputs.

(An example of how a complex system can be divided into components, is given in Section 2, where a "skilled manpower system" is sketched: The division between a "primary specialized training system" and a "job activities system" is usually necessary due to the tenuous relationship between training and work; in most cases, one would have to be content with intermediate indicators, such as number of certificates awarded in training, to judge effectiveness of the primary specialized training system, rather than seek to assess the ultimate goal of productive work outputs over a long period of time. At present, the evaluation of most job-oriented training systems is seldom carried beyond the stage of determining the number of appropriate initial job placements).

The schema given of the elements of a control system permits us to identify the steps in defining a monitoring system. To begin with, there must be one given, namely a general set of goals for monitoring, based on an understanding of the purposes which the data furnished is to serve. The functions proposed for an NIE monitoring system in the introduction may serve as an example. Once such goals have been set, the definition of a monitoring framework is possible. The steps are:

1. Definition of the boundaries of the system to be monitored, specifically by stating the grounds for including or excluding elements that might potentially be part of the system. For example, if one is going to study basic research in the field of psychology, one should state the definition to be used in deciding whether an activity constitutes research, whether research is basic or applied, whether it is psychology (as opposed to the biochemistry of neural processes), etc.

2. Definition of a framework of analysis which will permit data derived from monitoring to be related to the information requirements of users.

3. Specification of indicators to be used for observation and procedures for data collection, analysis and reporting.

It should be noted in passing that these steps correspond roughly to the organization of the subsequent sections of this paper.

But, if the underlying concept of monitoring is simple, its application to large, complex systems frequently appears hard and confusing. The major difficulties are usually resolved by the procedures outlined above: the subdivision of large systems into smaller components that are easier to study and the substitution of intermediate indicators of performance for the indicators of "final" performance which one would prefer to obtain. Given a policy-making framework conceived as involving the two functions of monitoring and making choices between alternative actions, it is obvious that the monitoring function is synonymous with the processes of observation used in empirical sciences. In setting up a monitoring system for the national educational R&D system, it will be necessary to choose judiciously what are the points in the system from which relevant data should be sampled and what are the best means for obtaining the data. But, in the end, there are no fundamental methodological obstacles to integrating data from widely disparate disciplines into a common framework. The obstacles are all practical: how to relate one data base to another and how to report intelligibly about such a vast, multifaceted system to a variety of publics.

D. USING THE FRAMEWORK TO DISCUSS COMMON MODELS OF R&D

1. Trends in the literature

A summary of the literature on educational research and development is beyond the scope of this paper. At most one can sketch a few trends of the literature and then examine how certain familiar models of educational R&D appear when cast in the light of the need for developing a monitoring framework for the NIE. Any discussion of this sort should be preceded by a clear disclaimer. Pointing out a "weakness" in a model does not imply a lack of competence, knowledgeability or performance on the part of the persons who created it. In most cases the models discussed here were developed with a clearly defined set of purposes and were adequate for those purposes. In fact, almost all of the discussion that follows will be addressed not to particular models but to a whole literature on models, from which examples are selected.

To schematize very broadly, the literature relevant to models of educational R&D approaches the problem from two major perspectives. One perspective is a sort of "inside" view, originating with persons involved either in managing, carrying out or using the results of educational R&D. The other perspective is an "outside" view of persons who have studied the progress of science or R&D as a whole and whose work therefore has some application to educational R&D; for the purposes of this paper, the most important of these outside perspectives is provided by work that treats R&D from the point of view of developing national accounts or national indicators.

A succint summary of the "inside" literature on educational R&D is given in Educational Research and Development in the United States (NCERD 1969, pp. 1-7). The summary is useful in that it points out that most literature in this area centers on one of either research, development or dissemination: "...there is not a great deal of literature on the relationship of research to development, or development to research, or the relationship of both to the improvement of education." (Ibid, p. 5). This situation has changed rather rapidly since the publication appeared. Perhaps spurred on by the mounting evidence that the results of educational R&D were not having a broadly significant impact on educational practice and partially in response to the interest surrounding the proposal to create the National Institute of Education, an increasing number of authors have dedicated their efforts to explicating the linkage between R&D and educational practice, or more correctly, to the failure to develop effective linkages. This change was already evident from the massive report of Del Schalock and Sell, known generally as the "Oregon Studies", published in 1972 (Del Schalock and Sell 1972). Other recent reconceptualizations and summaries of the literature have been produced by scholars both in the United States (cf. Havelock 1969, 1970; Pincus 1973) and abroad (Fullan 1973, Huberman 1973, Dalin, in press). Each of the authors cited as a more recent reviewer has also contributed significantly to clarifying the concept of an educational R&D system, marking an advance away from the failure to explicate relationships, referred to in the NCERD study.

As mentioned earlier, the national accounts approach to monitoring R&D began in the early 1950's with the survey work of the NSF. Since then the problem of monitoring R&D at the national level has been taken up elsewhere in the world, particularly under the aegis of international organizations such as the Organisation for Economic Co-operation and Development, UNESCO and the Council of Europe. Although attention was initially directed to the natural sciences, in recent years a significant literature has appeared dealing with monitoring activities in the social sciences (cf. Freeman 1969a & 1969b; Lefer 1971; OECD 1972; Trist 1970). This literature on the social sciences has begun, by implication, to include educational R&D. The NSF surveys do include research in the social sciences (and, therefore, in education), though they exclude development, truncating the R&D continuum at one end.

2. The "external" perspective : R&D in national accounts

The utility of the data furnished by the NSF for the concerns of the NIE will be dealt with in the last section of this paper. At this point, our objective is mainly to see how the monitoring model used by the NSF matches up with the conceptual framework outlined earlier in this section. At the present time the "state of the art" for national accounts of R&D systems is represented by the NSF surveys and, in particular, the recent publication *Science Indicators 1972* (National Science Board 1973). The basis of almost all such studies is to provide measures of *inputs* to the R&D process as if they were surrogates of *outputs*: that is, one measures the resources used for R&D, such as money spent, equipment purchased, skilled manpower employed, number of research institutions or organizations in existence and number of potential R&D workers trained. *Science Indicators 1972* goes beyond this by introducing the first large-scale attempt to measure R&D outputs on the basis of three types of indicators: number of scientific publications published by country, number of citations of literature by country and a so-called "patent balance" based on the ratio of the number of patents granted in each country to its nationals and to foreigners. In addition, there is an attempt to get at the indirect benefits of R&D by measures of productivity, technology transfer and balance of trade in technology-intensive products. An experimental section on attitudes of scientists and the public about science problems is also introduced, as a sort of indicator of the "environment" of the scientific system. The set of indicators is indicated in Figure 7 , a small adaptation of the monitoring model shown earlier. The main indicator sampling points are as follows: A. resource inputs (money, equipment, trained personnel); B. research results (publications, citations, patent balance); C. activity level (number of research organizations, persons employed); D. environment (opinions of scientists and public); E. indirect benefits (productivity, technology transfer and balance of trade).

Insert Figure 7 about here

The 1969 NCERD report Educational Research and Development in the United States should also be mentioned as the sole major existing effort at monitoring educational R&D from the perspective of national accounts. The "indicators" presented in the report involve, by comparison with the NSF studies, more reliance on narrative description based on secondary sources, than on direct measurement. The same indicators (dollars and numbers of persons) are used for resource inputs; with regard to indicators of process or activity level, the report includes narrative description of institutions engaged in R&D and the techniques of research management; the research environment is described in chapters on the history and on the organization and current problems of education in the United States; outputs are assessed in chapters describing major recent programs and studies. In other words, the framework transposes exactly to the schema given in Figure 7 for the NSF monitoring system, with the exception that the indicators are generally subjective. On the other hand, from the point of view of a person interested in formulating policy on educational R&D or understanding how it operates, the NCERD study is far more interesting and informative than would be an adaptation of the NSF methodology to the field of educational R&D. The tradeoff between objectivity and relevance of indicators is as much a problem for science policy as for any other field.

3. The "internal" perspective

If we examine the literature written from the "internal" perspective, it is clear that most are partial models of one portion or another of the monitoring schema, usually the process at the center of it. For this reason, transposing them against the monitoring schema reveals little of interest. It is probably more appropriate to select a few familiar examples of model types and rephrase them in terms of the language conventions mentioned above, pointing out their relationship to the monitoring schema

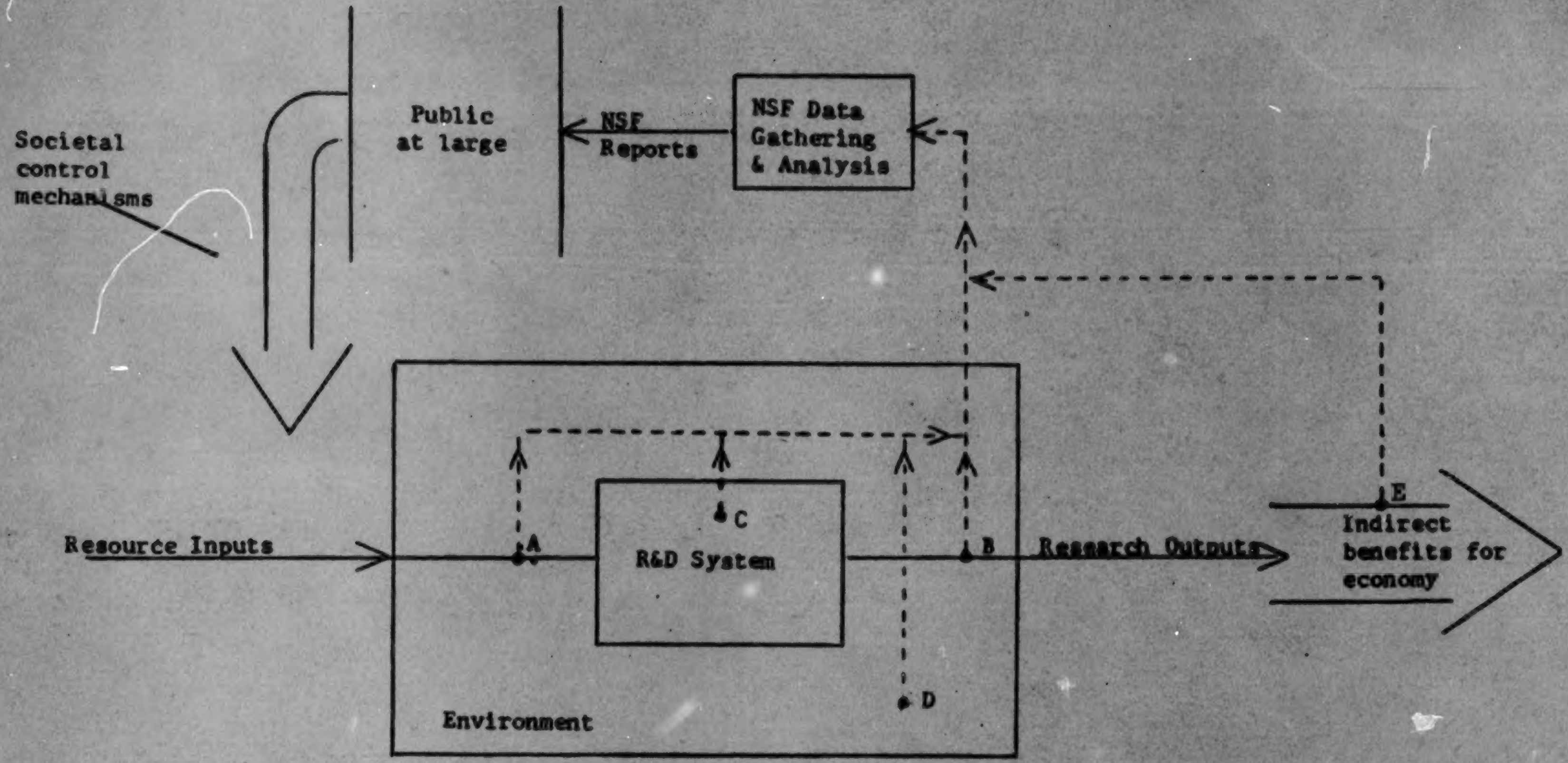
Societal control mechanisms
Public at large
NSF Reports
NSF Data Gathering & Analysis
Resource Inputs
A
C
R&D System
B
Research Outputs
D
Environment
E
Indirect benefits for economy

Figure 7. Schema of NSF monitoring system for U.S. R&D effort

only where it is not self-evident. Before we begin, it should be pointed out to readers who lack familiarity with flow charts and diagrams, that the graphing conventions typically used to illustrate models have the property of "mapping" into each other on a basis of exact equivalence, e.g. a flow model using boxes and arrows to illustrate relationships between elements can easily be transposed into a data matrix format familiar to the veteran reader of statistical tables or analyses of experimental data. Difference in presentation format should not hide the underlying unity of the conceptual framework.

A good part of the model literature can be seen as describing the roles of agents. This could be graphed as the correspondence between two lists :

Insert Figure 8 about here

The list headed "Roles" in the figure is usually comprised of a list of activities that can be carried out by the agents, in the sense of an explicit or implied division of labor. These taxonomies are based upon a sequence of activities deemed to be "necessary" or "natural" for research and development, e.g.

Insert Figure 9 about here

or in the usual taxonomy :

Insert Figure 10 about here

Although some authors' analyses introduce finer detail, those refinements consist primarily of subdividing and describing in greater detail the possible roles that may be assigned to different agents, e.g. in the model of Guba and Clark (1968):

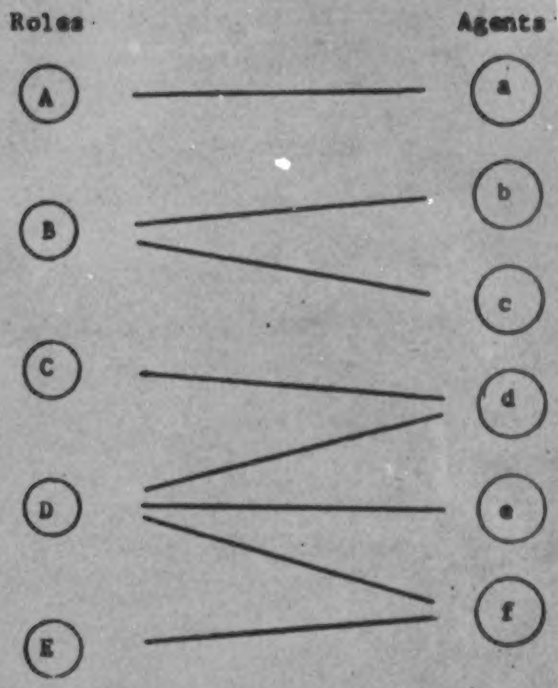
Roles
Agents
A
B
C
D
E
a
b
c
d
e
f

Figure 8.

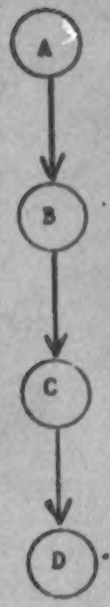

Figure 9.

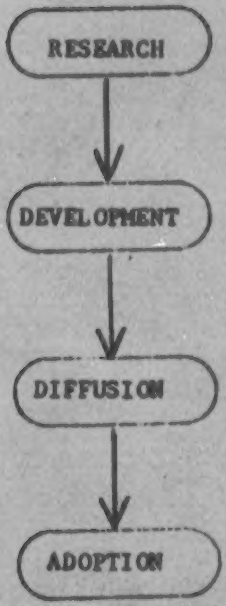
RESEARCH
DEVELOPMENT
DIFFUSION
ADOPTION

Figure 10.

Research	Development	Diffusion	Adoption
	-invention	-dissemination	-trial
	-design	-demonstration	-institutionalization

Without essentially changing the framework Del Schalock and Sell (1972) carry the process one step further, basing their primary definitions upon the construct that research, development, evaluation and diffusion are problem-solving strategies, i.e. a means to achieve a desired goal. Remarkably little attention is given to the problem of goal definition. As such, the framework they propose is most useful in analyzing the instrumentalities of research and development rather than its end; it provides a series of categories for classifying descriptive data on organized, institutionalized research and development activities. The essential limitations of the framework for the purpose of describing a national system of research and development in education can best be seen by situating the Del Schalock and Sell article in a larger framework. The two authors can be viewed as contributors to a process of policy-making on educational research and development, in which they appear as proponents of a particular school of thought. The triumph of their definitions (or a related set) as the de facto norm, for example, in granting public financial support to R&D and managing R&D projects would have certain unsatisfactory implications. The limitations of their approach---limitations consciously adopted, it should be recalled---are clearly evident in a footnote to the paper, in which the authors acknowledge that they have given "a relatively narrow definition of research if the inquiry related activities of the mathematician, historian, and philosopher are also to be considered" (Del Schalock and Sell, 1972, p. 215). When describing a national system of educational R&D it would require considerable lack of political horse-sense to exclude such researchers from consideration, even if they are usually given short shrift when it comes to awarding research funds. Conversely, when searching for ways to categorize institutionalized R&D of the type Del Schalock and Sell set out to describe, it would be equally shortsighted to exclude their taxonomy from consideration as a potential basis of data collection and/or analysis.

Most of the literature dealing with research and development as a mechanism of planned change has been spent on prescriptive definitions of the process as viewed by those who propose to plan, manage and induce the changes. The examples cited briefly above are illustrative of a whole school of thought, concerned with improving the effectiveness of R&D as a change mechanism. An almost opposite approach is to be found in a part of the literature describing the process from the point of view of the "object" of the planned change---the "user" of R&D, the "client", etc. Although much of the literature, reviewed in the articles cited earlier, is concerned with similar prescriptive definitions of roles (change agents, leaders, linkage agents, etc.), the descriptive approach is strongly represented. The conceptualization of change as a "diffusion" or flow process has resulted in many important insights, though not so many as to prevent even major blunders by researchers. As the recent article by Fullan (1973) points out, many of the studies of diffusion have been based upon very poor data sources, exaggerating the role of authority figures in the diffusion process. A principal's announcement of the adoption of an innovation is not proof that the innovation is being used by the teachers in his school.

The problem appears to be with poor application of flow descriptive models, not with the underlying concept of the models. Upon analysis, these models of change can be seen to fall into two general categories. The first is a variant of the sociogram, a charting of influence patterns, e.g. how influential is a given superintendent, as indexed by the number of other superintendents who report following his lead in adopting an innovation:

Insert Figure 11 about here

The model reduces to a group of agents, superintendents, linked by a simple relationship, reported influence, and charted against a dimension of time periods. The second type of model is some variant of a message transmitter-receiver model; Havelock's definition of the linkage model (Havelock 1973, pp. 8-9) can serve as the prototype:

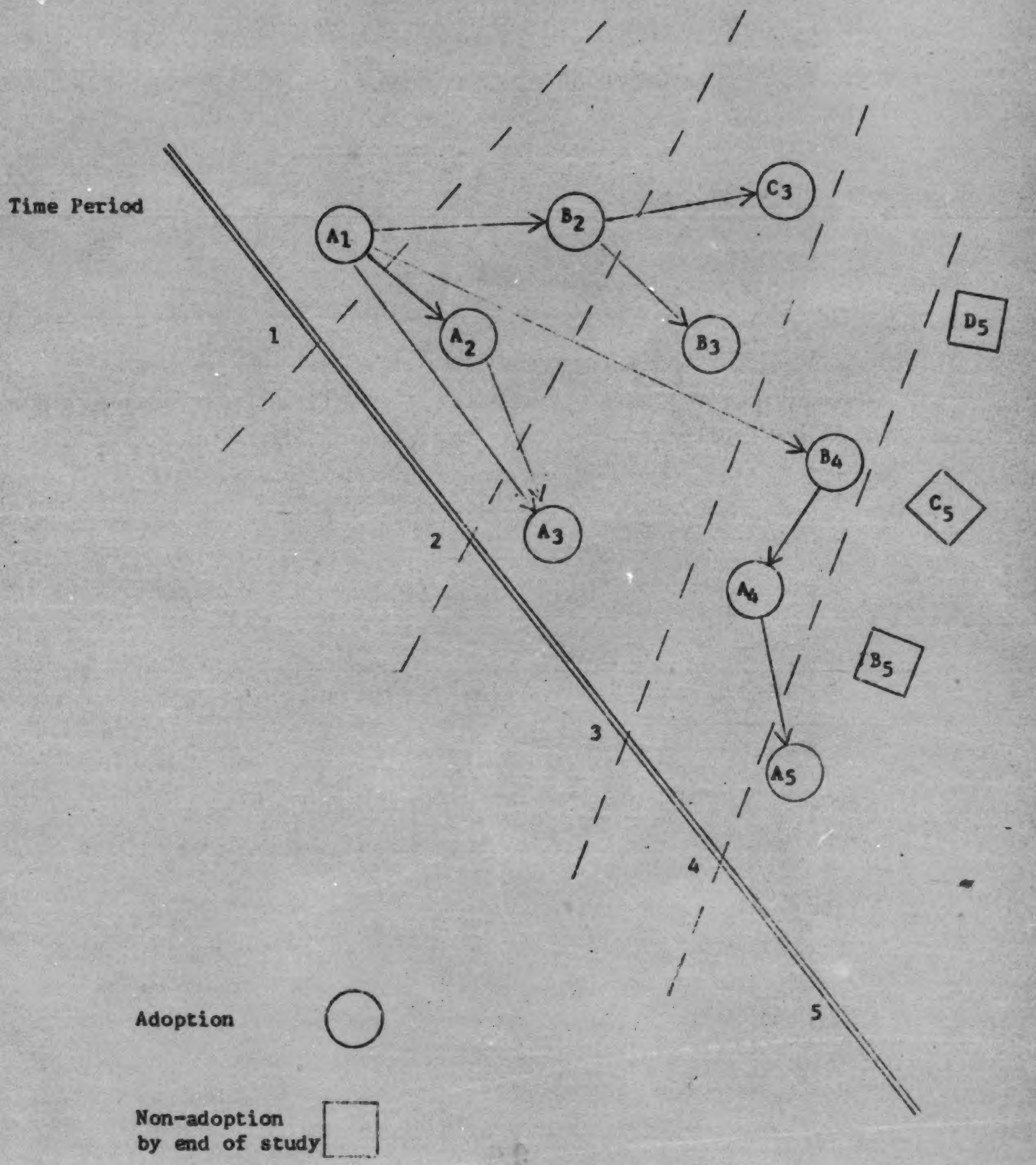
Time Period
A1
B2
C3
A2
B3
A3
B4
A4
A5
D5
C5
B5
1
2
3
4
5
Adoption
Non-adoption
by end of study

Figure 11.

Insert Figure 12 about here

where L is the possessor of expert knowledge (the "linker") and U is the person who has an existing or potential need for that knowledge (the "user"); this reduces further to a message transfer either from user to linker or linker to user:

Insert Figure 13 about here

In terms of our vocabulary conventions, this event can be seen as the interaction of two "agents" consisting of the "flow" of a "message". Such events are usually traced against two frameworks, i.e. the flow of a given message or class of messages along a chain of agents

Insert Figure 14 about here

or the time sequence of events affecting the agent in a given period:

Insert Figure 15 about here

or some variant of the above.

A final class of "models" is constituted by the implicit models built into studies which have been done on the operation or constitution of some components of the R&D system. In the process of defining a research problem, deciding on a data collection framework and analyzing results, researchers have explicitly operationalized definitions of one

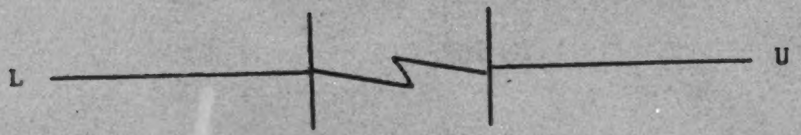

Figure 12.

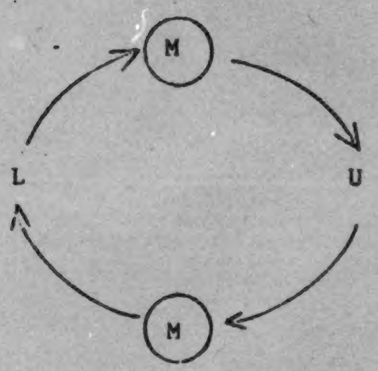

Figure 13.

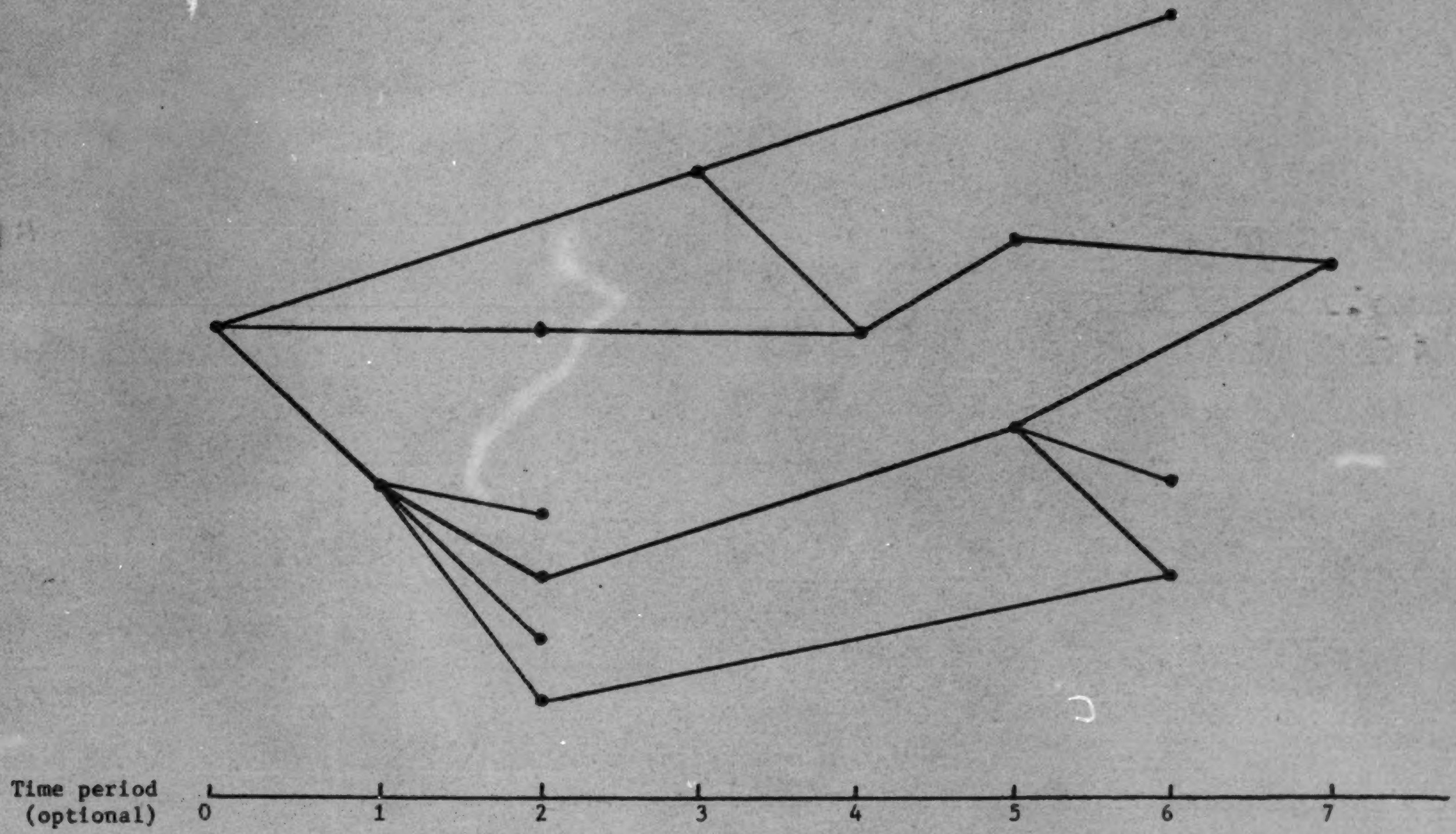
Time period
(optional)
0
1
2
3
4
5
6
7

Figure 14. Example of a message transmission network

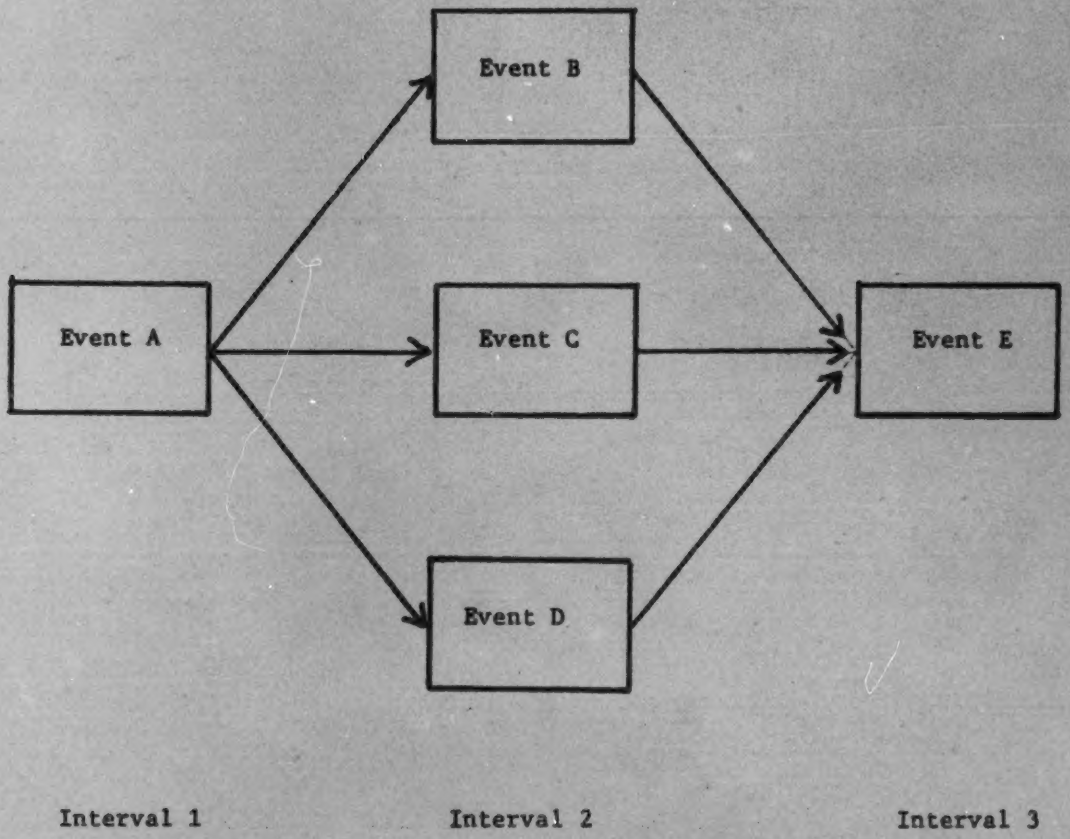
Event B
Event A
Event C
Event E
Event D
Interval 1
Interval 2
Interval 3

Figure 15. Series of events sketched against a time sequence.

or more portions of the R&D system. Typical examples of this type of research include the work by Sieber and Lazarsfeld (1966) on organizational patterns of research and by Clark and Hopkins (1969) on the supply of trained manpower for educational research, development and diffusion. In most cases, such research on the system is based on definitions or schema already known in the literature, of which the major prototypes have already been dealt with here.

Two points should be made about this brief review of models of educational R&D: The first is that the vocabulary conventions and monitoring schema is adequate to deal with these cases. The second is that, despite the large amount of literature written on the subject of educational R&D in the past few years, there are surprisingly few attempts in the literature to describe how the whole system interacts. The 1969 report by NCERD remains the sole integrated attempt to describe a full range of institutional sponsors and performers of educational R&D and the associated financial support. Even that study hardly scratched the surface, dealing primarily with R&D serving the K-12 educational system and funded by the federal government or private foundations, from which very gross estimates of funds granted were obtained on a one-shot basis. Other sectors were dealt with only summarily, if at all. Rather than call these omissions "limitations", one should probably point to them as good indicators of the realism that went into writing the report: major interest attached primarily to the K-12 system; the only available data for writing covered the public sector. Because these constraints continue to prevail, the justification of the present paper is that it is intended to assist in discussing longer term issues.

Section 2. Defining System Contours: The Major Problem Areas

In the previous section we have defined a proposed framework of discourse and shown how it relates to other frameworks for discussing models of research and development. The discussion of previous models is only sketchy and does not do justice to their content; its purpose has been to show how the structures of models map into the framework, not to discuss the contents of the structures. It is hoped that this initial application will be helpful as an introduction to the next set of issues: How can one expand the concept of the national R&D system? The 'expansion' of the concept poses, in turn, of course, the problem of relating the expanded system to a reporting and monitoring framework, which is the last section of the paper. For the moment we shall concentrate on: (1) identifying aspects of the R&D system likely to be of interest for policy or research (2) exploring their general content as broadly as possible. In other words, we are casting our net wide in this section, not being hampered by problems of actually getting data on the phenomena discussed.

If asked directly the question "What is the national educational R&D system and what is its current status?" most knowledgeable persons would be inclined to think immediately of the network of existing institutions which carry out R&D functions. Their personal definition of what constitutes an "R&D function" would be the criterion defining what the system is, and a description of the institutions carrying out that function would constitute, therefore, a description of the national educational R&D system. In all likelihood, that description would include "institutions" that are broadly defined, much along the lines of the term "agents" introduced earlier. Our purpose in expanding the concept of the R&D system is not to reject the concept that the institutional framework is probably the principal element involved in such a description; it is rather aimed at two goals:

(1) Increasing the number of agents included in the description to match a broad concept of what constitutes an educational R&D function.

(2) Refining the types of analysis which are used in arriving at a description of the system, emphasizing the interactions between the elements in the system.

The procedure used will be to begin with a definition of educational R&D so broad as to include most alternative definitions. Using this definition as a central vantage point, we shall examine a series of "subsystems" that seem to lead outwards from it. (The process is roughly analogous to that of the astronomer who looks from the world outwards to chart the contours of the observable universe). Generally speaking it will be clear that the subsystem can involve a changing variety of "agents." In cases where the agents involved are not clear from the discussion or where there are so many possibilities that the "expanded system" concept becomes unmanageably large, an attempt will be made to describe the agents explicitly. Otherwise, no description of agents will be undertaken in this section.

As far as possible, an attempt will be made to deal with the subject matter in terms which are familiar to the general reader and to explain those which are not. The sequence of presentation will be:

(A) Knowledge organization and utilization, or the R&D "flow"

(B) Media and message systems

(C) Resource inputs to R&D

(D) Regulatory systems

A. R&D IN THE PROCESS OF KNOWLEDGE ORGANIZATION AND UTILIZATION

1. R&D: A model and a definition

In an appendix to this paper I present a model of the process of knowledge organization and utilization based upon the interaction between the societal knowledge base and humans, either as individuals or groups; it is characterized by the summary title "an information-agent interaction model." The model has the characteristic that it accommodates within its framework the three major change models identified by Havelock (1971): research and development, social interaction and problem-solving. Each of the change models, when viewed in this framework, appears to be characterized by its assumptions made as to the source of change processes; these sources are, respectively, increase in usable knowledge, knowledge distribution and assimilation, and (self-) organization of user needs.

The information-agent interaction model is presented, not because it is assumed to be The Model of knowledge utilization, but because it parallels the accommodations made by public policy on research and development in recent years: without abandoning the concept of rational change based upon the planned development and exploitation of knowledge resources, public policy has tended to add to this process by focusing on interventions aimed at penetrating the user system, viewing the processes of social interaction and problem-solving as delivery mechanisms whose characteristics should be taken into account when organizing the R&D process or, where circumstances permit, manipulated to suit the objectives of the R&D process. The author is convinced that the practice of research and development in education will have to go much farther in accommodating itself to change processes in the educational system, if it is to be an effective instrument of social policy; in other words, the concept of research and development will have to be re-defined to include a dimension of social receptiveness to change as one of its integral goals and modes of operation.

Two major implications of the information-agent interaction model should be kept in mind during the discussion that follows:

(a) The distinctions between "researchers", "developers", "change agents", "linkers" and "users" are useful role categorizations for visualizing functions within specific types of research and development, but they do not apply to all modes of development. They are, so to speak, language conventions based primarily upon the perceived ends or objectives of activities, not upon essential differences in the basic process of the activities. Above all, there is no implied division of labor between persons or agencies following the lines of these distinctions. (b) Since organized, formalized scientific research is only one of the means by which the societal knowledge base is increased, research is not to be perceived either as the sole source of change or the sole source of knowledge inputs to the R&D process.

In combination, these implications have various side-effects, the most important of which is to put the role of the researcher into better perspective, probably reducing its significance by comparison with the perception of members of the research community but still maintaining it in a more central place than public opinion would assign it, at least for applications to education.

Using the model as an instrument for visualizing the boundaries of the R&D system, one if faced with an important choice point. If one looks at the process from the research end, so to speak, attempting to determine how basic research eventually reaches practice, one gets a very limited view, one very close to the models of research and development prevalent in fields such as cancer research, where extreme emphasis is placed upon unravelling certain basic biochemical processes of the human organism; in the end, however, it is obvious that, in the public health system as a whole, cancer is only one of a number of potential causes of death and, even if a cure could be found, there would still remain massive problems of organizing the delivery of health services to the population as a whole. The problem is a direct analog of research and development problems in education: the physical well-being of the population is as difficult to improve as the level of education, and as dependent upon individual choice and circumstance (except that law forces part of the population to accept education but does not require visits to the doctor).

If one turns the model around and considers it solely from the point of view of the user, a similar distortion results, only in the opposite direction. Instead of being too narrow, the view is too diffuse. The knowledge applied by any "user" of R&D is ordinarily based upon the entire cultural knowledge base available at any given time; popular myth or local circumstance may be more important at a given moment than the results of recent discoveries of science. The true believers in R&D react immediately and instinctively against legitimating such a diffuse process; they reject the idea of tinkering at social change without a systematic or scientific basis, though this is historically the main way in which social change has occureed. Intuitively, one has to agree with them: any application of knowledge is not necessarily R&D. Conversely, one also senses that R&D cannot be limited so that it includes solely the use of scientifically "proven" knowledge, since this would imply that science has found the answers to all problems that will be posed. This is manifestly incorrect.

The practical problem is to reconcile the two extremes of accepting basic scientific research as the only source of usable knowledge or accepting a system in which the results of methodical research are given little or no importance. To be precise, the agent-information interaction model permits us to describe situations in which scientific knowledge is found without intent or immediate probability of application as well as those in which social or other change occurs without conscious or explicit reference to a scientifically established knowledge base. Within the broad range of possible situations fitting within the model, we shall define R&D as the systematic attempt to manage or improve the efficiency of the flow of scientifically established knowledge into use. This definition hinges upon the operational sense given to the words "systematic attempt"; depending upon who is applying the yardstick, the measure will be broader or narrower. It is an obvious corollary of this definition that educational R&D is the application of R&D to improving the flow of scientifically established knowledge into use in education. Here, the obvious hinge word is "education." Again, its meaning will have to depend upon the user. In proposing to use this model of R&D as a basis for expanding the boundary of the national educational R&D system, we shall have to pay particular attention to these two concepts.

If the beginning point of the concept of educational R&D is education, the focus of education is the learner. Let us define the education process (as opposed to the "education" or culture" communicated to the learner by the process) as the systematic organization of learning experiences. The definition will hardly do for a learned treatise on the philosophy of education but it is certainly congruent with most of what we all mean when referring to education and includes a lot which is frequently overlooked in practice. Let us take a simple example: a recent survey of literature on change in the school system by Fullan (1973) found that most articles concerned with the question of how the user viewed R&D and applied it in practice tended to equate the "user" with the teacher or educational administrator employed full time in the school system. Rarely, if ever, was the learner or pupil viewed as the user of educational R&D! For the moment, we should retain the notion that learners exist in other settings than the publicly-supported system of schools and colleges of the nation. As we set about exploring the boundaries of the educational R&D system, each area explored will have associated with it a body of learners whose learning experiences are the "target" so to speak of education R&D.

2. The publics for educational R&D

The basic stratagem for "expanding" the concept of educational R&D is to look more broadly at the types of educational experience served by the R&D activity. At the present time, most of what is recognized generally in the United States as educational R&D serves the educational sector symbolized in the following diagram:

Certification-oriented

State Private

This sector of education is what we refer to generally as "public education": the k-12 system with its extensions, in one direction to include pre-school programs, in the other to include colleges and degree-granting post-secondary institutions (including professional and graduate schools). Though some institutions are state-supported and others derive their income from private sources (churches, private donors), the system is generally viewed as a whole for most public purposes, such as the definition of educational R&D programs. In practice, the post-secondary sector is usually not thought of when speaking of educational R&D. Such an exclusion hardly appears justified. When a federal agency such as the National Institutes of Health makes a grant to a medical school for the purpose of revising and improving its teaching program, it is subsidizing an important type of educational R&D. Since large numbers of other types of institutions grant vast numbers of certificates and diplomas different from those of the sector just described, we should perhaps clarify the title to say explicitly "primary certification." (Though many persons leave the system and return later to complete their studies for a given degree or level, most structures are clearly oriented towards the concept of a sequential system providing initial training to younger persons prior to entry to the economically active population).

The primary certification sector can be opposed (rather simplistically, it is true) to the task-oriented education sector, as symbolized in the diagram below:

Primary certification sector		Task-oriented sector	
State	Private	State	Private

The title chosen for this sector is not intended to suggest that the primary certification sector excludes training in specific tasks or professional duties; it is simply a short title for a complex reality. The sector includes generally those types of education programs organized for the purpose of helping a person to carry out a job; though not always, the programs are generally conceived as following on from some level of general education obtained in the primary certification sector. There is no implication that the content of the courses deals with narrowly-defined trade skills: foreign language training programs for Peace Corps volunteers, special general culture seminars for executives in need of "broadening", sensitivity training sessions, all fit in the category easily. Most of this sector is overlooked in discussing or planning educational R&D for the purposes of governmental policy; the only areas specifically included are the in-service training of teachers employed in the primary certification sector (either in-service training in general or dissemination programs aimed at the teacher as an adjunct to R&D programs directed at the classroom) and the training of recruits into special governmental programs (Peace Corps, certain poverty programs). The areas generally excluded are: internal training programs of employees in the private sector, most internal training of public employees, training programs of the military. The fact that these areas are seldom thought of as part of the clientele base for educational R&D does not mean that there are no R&D activities underway initiated within the private sector and the government. In fact, the amount of systematic, highly organized program development in these sectors is probably much greater than all that is done in the name of educational R&D for the primary certification sector.

What is more, this is true if one limits the idea of education solely to the presentation of systematic classroom programs or some variant of them using electronic or audiovisual media. If one also includes the private sector analog of what is called "general culture" (or something like that) for the primary certification sector, then the balance shifts drastically. Here I am referring to the question of employee information programs intended to keep them up to date with the state of the art in their field, particularly as regards changes in technology and products. The problem is an enormous one of in-service retraining, frequently involving a combination of numerous methods within a carefully planned framework. Some major industries -- the computer industry is particularly well known but not unique -- involve periodic technological upheavals that require the nearly complete retraining of a majority of the professional work force. The success stories of certain firms which are successful in their internal retraining programs for technological change should not blind us, however, to the certainty that there are at least as many failures, marked by the human "dropouts" from economic sectors where the replacement of the humans involved was either implicitly or explicitly the consequence of inadequate internal training mechanisms. In a society verging on the welfare state, there is no certainty that the final cost equations based on lower training costs within the enterprise are not counterbalanced by other social costs measurable in financial terms, quite independently of the humanitarian problems involved. This means, essentially, that the "task-oriented sector" defined here is both: (1) one of the largest producers of educational R&D in the nation (even by narrow definitions of R&D) and (2) one of the major areas of need for further educational R&D. As such, it has a place of privilege in any expanded concept of a national educational R&D system.

It is axiomatic among professional educators that education is not solely preparation for a job. The broader definition of educational goals to include personal development and fulfillment leads us to point out that the sectors discussed thus far amount to formal education. In order to be complete, our diagram should look as follows:

Formal education

Primary certification sector		Task-oriented sector	
State	Private	State	Private

Informal education

State	Private	Cooperative	Familial

Our earlier definition of R&D included the terms "systematic attempt to manage or improve the flow..." The reference to "systematic attempt" carries with it a strong connotation of an institutional base: Does this exclude informal education? Certainly it excludes a good deal, particularly the individual learner's attempts to improve his own lot by organizing his learning experiences more effectively; that he could do this in a systematic fashion making use of scientific basis is not denied; it only appears to be too big a problem to deal with here, too diffuse to be of interest for the immediate future as part of a national R&D system. But, to say informal, does not mean non-institutional. There are numerous state-supported institutions whose main role is to foster individual learning: libraries, museums, art galleries and numerous other institutions that cater to the general cultural (with or without a capital 'C') needs of the population as a whole. Much effort is also put into enterprises that are labelled with titles such as "public information programs" (e.g., on personal health problems) or "consumer education"; these fall clearly within the requirement that there be an institutional base. Systematic attempts to devise better techniques for these programs using the fruits of scientific research on media effectiveness, for example, would probably qualify for almost anyone's definition of educational R&D, provided one does not limit the scope solely to formal 'schooling' techniques or the education of the young. There are also, of course, numerous private enterprises of a commerical nature which serve the varied needs of the population for information and learning experiences. For purposes of clarity, we will classify these under the category of "private", using the categories "cooperative" and "familial" to deal with two other major realities of the informal sector. Cooperative non-profit organizations of many types are involved in educational endeavours of the most varied sorts. The family remains the basic element of informal learning by the young and, particularly, the very young; that there is much which is traditional in child-rearing practices does not exclude them from being the objective of systematic scientific study aimed at their improvement. Public policy on educational research and development may choose to ignore informal education altogether or various parts of it; but to do so is to ignore also the major portion of the learning experiences of the majority of the population.*

3. Boundary criteria

This discussion of groups served by education, broadly defined, has led to an expansion of the potential system boundary of educational research and development to include most of the information processing and creation capacity of society. At some point, it is necessary to begin establishing boundaries. Our problem arises, in this respect, from the fact that our society is pluralistic and we must therefore assume that the definition of system boundaries will evolve over time in relation to shifting goals. This has been pointed out in a recent article by Eide (1971) in the following terms:

> In terms of goals, it is fairly generally accepted in principle that the goals served by education are not exclusively "educational". Most social goals are influenced by educational activities. On the other hand, in hardly any case is education the only activity serving those goals. It is virtually impossible to establish a set of independent goals for educational policy. When attempted, it leads to disregard of essential consequences of educational activities, and of non-educational factors influencing the stated goals.

Under these circumstances, the best we can hope to do is to establish very general criteria for selection of system components, aware that any concrete application of this framework will involve specifying more precise boundaries. A set of general criteria are proposed and then a number of specific problem areas are discussed; one of these areas, that of media and message systems, is of such dimensions that it is dealt with in a separate section.

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*It is symptomatic that the education reform law recently adopted in Peru gave explicit recognition to informal education on a legally equal footing with formal education and defined as one "mode" of informal education the family, primarily with reference to infants.

The general criteria can best be visualized as partially or wholly overlapping circles, in the symbolism of Venn diagrams:

Insert Figure 16 about here

The first criterion, symbolized by circle A in figure 16, is by far the more general; it refers back to the definitions given above, namely that we should include only activities related to education:

c1) Relationship to the needs of an identifiable educational public (i.e. to one of the three sectors referred to above: primary certification, task-oriented and informal).

Within this domain, one can look for organizations whose activities are intentionally geared to serve the educational needs of those groups; this may apply either to a private school or a public school, to a private business firm selling, for example, textbooks, or to a state agency developing public information programs. The bulk of the activities carried out in such organizations is probably not what one would wish to consider in any narrower definition of R&D, certainly not in one which makes reference to usage of basic research inputs as part of the process. Nevertheless, from the point of view of potential for R&D, these institutions constitute a field where

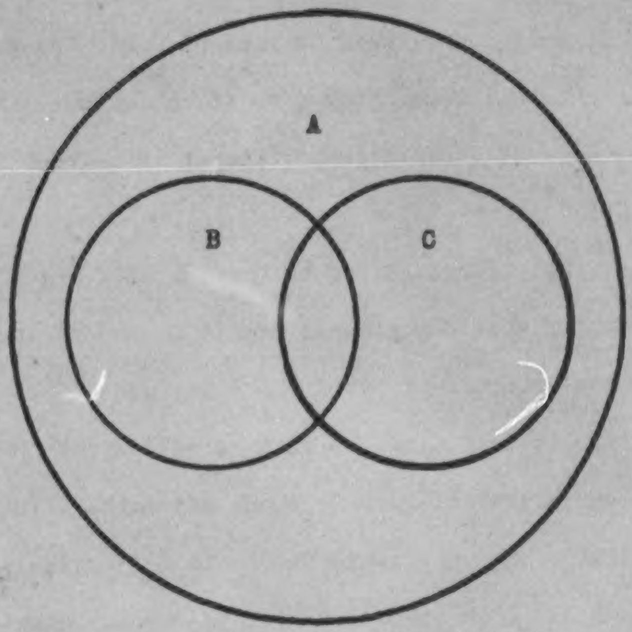


Figure 16.

organizational change and shifts in modes of operation might occur in the direction of greater capacity to carry out R&D, narrowly defined; the implications of such change would be enormous. What is more, in almost all cases some R&D is being done, even at present. For the purposes of monitoring on a national base, they have to be included, even though the monitoring will reveal only a small proportion of activities fitting a narrower definition of R&D.

C2) Those institutions having as a major activity the education of an identifiable educational public should be included as potential sources of R&D for the purposes of monitoring. (This is symbolized by Circle B in diagram ivA1).

Two questions arise: (1) How does one determine which activities inside educational institutions constitute R&D? (This is symbolized by the overlap between Circles B and C in Figure ivA1). (2) What educational R&D goes on outside the framework of educational institutions? (This is symbolized by the portion of Circle C which does not overlap with Circle B in Figure ivA1). To determine this, a set of criteria are required which center around the concept of what constitutes an R&D activity. As bases for selecting activities for inclusion within the concept of R&D activity, four types of criteria appear to be in use, either singly or in combination:

C3a) Generalizability of activity results: The applicability of results to more than one user, more than one situation. The definition of generalizability is frequently dependent upon a corollary assumption, that research results derived in a "scientific" manner have wide applicability and are not case-specific. This corollary may be useful for certain applications, but not all.

C3b) Conscious use of a particular methodology of work: the concept of "disciplined inquiry" as broadly defined by Cronbach and Suppes (1969) constitutes a criterion of sufficient generality to be applied to most situations required in defining a national monitoring framework.

C3c) Durability of results: many current definitions of R&D as a change-oriented methodology obviously imply the inclusion of information systems and the general "delivery capacity" for effecting change, including the mechanisms used for planning change (defining goals, specifying objectives, selecting means, etc.). Obviously, all planning systems and all information systems are not part of any current definition of R&D, so that some criterion of selection is required; the most useful, when applied in conjunction with other criteria, is that of durability of change being sought.

C3d) Novelty of an activity or its results: the basic definitions of R&D used for the survey of the National Science Foundation (cf. NSF 1972 p. 39) exclude activities which are "routine," such as product testing or experimental production from the definition of research and development. This is in general agreement with international practice. For example, the Unesco surveys of R&D also exclude "routine" activities from consideration and define "experimental development" as: "Systematic use of the results of fundamental and applied research and of empirical knowledge directed toward the introduction of new materials, products, devices, processes and method - or the improvement of existing ones - including the development of prototypes and pilot plants" (cf. facsimile questionnaire, Freeman 1969b, pp. 41-42). The phrases underlined (by the author) indicate the emphasis on novelty, which is amplified in the OECD guidelines for surveys (OECD 1970, para. 31, p. 12): "The criterion for distinguishing R and D from non-R and D activities is the presence or absence of an appreciable element of novelty."

The intent of the definitions quoted is to assure that "scientific" activities are not confused with the mundane world of day-to-day production, administration and instruction. The affect, when applied to educational R&D (broadly defined) is to remove from consideration numerous areas of crucial importance, if R&D is considered as a mechanism for changing educational practice. For example, evaluation of educational products prior to adoption decisions is excluded from NSF surveys of R&D, as are activities related to informing potential users or adopters about new products; the whole range of activities usually grouped under titles such as "dissemination" or "linkage" and "implementation" is excluded. (A small portion of these activities is included as "other scientific activities" in broader NSF surveys, cf. NSF 1971). From this cf is clear that the criterion of novelty is primarily useful for separating out within the broad spectrum of R&D activities thou which are clasest to a narrower, science-based conception of R&D.

The use of these criteria is no easy matter and must obey a number of specific constraints in any given application. Various systems of classification have been proposed which deal with the application to school systems either as regards the definition of innovations in schools (cf. Havelock 1970 and literature cited above) or as regards research and development activities (Brickell). Major definitional problems arise at the two extremes of the R&D flow described earlier, the question of general social science research and the generalization of the educational R&D framework to the non-educational agency.

4.) Special case one: 'Basic' research

It is an article of faith among some scientific circles that basic research is 'purer' the less anyone can define a use for the results. If, by definition, R&D requires that there be something called "educational research", how does one go about defining it at the basic end of the spectrum without including the whole range of the social sciences? As the paper by Eide (1971), cited earlier, phrases it:

> ..it is sufficient to state that research needs emerging from educational activities go far beyond what can be met by "educational research" as defined in most university settings. This implies that the relevant research instruments are not specific to education..(p.25)

Relating the definition of educational research to policy initiatives raises even more fundamental problems. To quote Eide again:

> What appears to be high efficiency in research performance may thus, in fact, reflect inadequate formulation of sub-goals in the field of policy concerned. A proper formulation of such sub-goals in terms of a general goal structure of society might prove that the present answers provided by research are not only insufficient, but even misleading. (p.26)

Faced with the awesome choice between including all of the basic sciences in the system and thereby making it impossible to monitor or using a limited definition and thereby risking leaving out entirely some research area whose results may be eventually earthshaking, one is obliged to choose the latter. The criteria to be used will obviously be linked to perceived applicability to education, so that the types of research included will be primarily applied, rather than basic. The exception would be the case where a research institution's activities are included en bloc on the grounds that the institution is specialized in educational research and some basic research happens to be maintained (or bootlegged) in the institution. The criterion here becomes:

C4) Research activities will be included which are of perceived applicability to educational problems as currently understood. Basic research in social sciences dealing with problems not currently preceived as educational will be excluded.

As with other criteria, this one will require the development of operational definitions for classifying data in specific cases.

5) Special case two: non-educational institutions

The generalization of educational R&D concepts to the framework of non-educational institutions presents a number of difficult problems. To begin with, the institutions themselves rarely conceive that the tasks they carry out involve an "educational" component, unless the training function involves the use of a formal classroom situation. 'Education' and 'schools' remain inextricably intertwined in the consiciousness of most persons. "Vocational education", even carried out in classrooms, frequently is relegated to a place of illegitimacy by using some catch-all phrase such as "training" or "skills training" to distinguish it from the world of "education." While the debate is both philosophical and practical as to the relative values to be placed upon these views of 'education', a national monitoring framework cannot afford to take sides; it must recognize that two sides exist (or however many sides appear appropriate in this context). In a large number of cases, the criteria mentioned earlier (point 3, sub-items a,b,c) can be applied to determine whether an activity "qualifies" as R&D. The following problem areas seem noteworthy:

a) With regard to "generalizability", one is forced to note that many situations in public institutions and private businesses are unique. To take a straightforward example: The Department of Defense may have designed a new weapons system requiring the training of several hundred persons under conditions of "quality control" unparalleled in the public education system; in order to achieve this, very highly sophisticated techniques may be needed to create the training system, and these techniques would be instinctively recognized as being those used (perhaps less efficiently) in R&D for public education; yet, are the results "generalizable"? The system will certainly be used in only one establishment, within one institutional framework and, in that sense, is not generalizable. In order to include it, the classification scheme will have to be based upon weighting of other criteria, such as methodological rigor ("disciplined inquiry") or some specific teaching characteristics such as the likelihood that the system will work almost independently of the human "teachers" involved (if any are at all, which is not altogether certain in some types of training).

b) Organizational internal information systems are not the direct analog of a 'dissemination' function in public education; the latter is intended to keep an educational practitioner informed. The business information system that would qualify as part of the "task-oriented education sector" would be analogous to a diffuse classroom situation, as the recipients are perceived as the final learners in most cases.

Yet, obviously, most business and public employees regularly receive a multitude of messages such as letters, memoranda, circulars and telephone calls, none of which would really be deemed educative in even the most narrow vocational sense. Still there are businesses which plan, for example, selective dissemination of information systems which keep professionals up to date in their areas of work; the educational function of the systems is indisputable, and the artifices that go into their design, implementation, evaluation and improvement are indistinguishable from the tasks carried out in what one would recognize as traditional educational R&D. The line is hard to draw and will require the development of specialized taxonomies based upon overlapping considerations:

C5a) The degree to which the information function is task-specific or skill-specific (to coin a pair of phrases): "Task-specific" information is related to the task at hand and does not have as an intended outcome the development of skills generalizable to other tasks; "skill-specific" information would have as its objective the development of generalizable skills. Skill-specific information would be the underpinning of both "specific training" --- usable only in the same firm --- and "general training --- which raises productivity of the worker irrespective of which firm he works for --- to borrow the distinction made by Becker (1964). One highly useful indicator is the degree to which the messages in the system have a personal content, i.e. whether messages are addressed to the employee as an individual (task-specific) or as a member of a class (skill-specific) and whether the message origination depends upon the initiative of an individual or is the result of a systematic procedure. The design of routine data processing systems for administrative purposes would be similarly exlcuded; the "gray area" would consist of the business system having special informational sub-systems built around a data-base concept; inclusion or exclusion would presumably be based upon an analysis of the origin of the data and its usage, but any classification scheme is likely to be arbitrary in the extreme under these circumstances.

C5b) The methodology used in developing the system: The formulation of the objectives of the information system, particularly if they appear to be of a general nature, would be one of the *prima facie* indicators of the nature of the information system; recourse to methodologies recognizably applied in development of educational systems in other sectors (specification of objectives for learner performance and parallel development of testing instruments by formal procedures as a means of assessing system or learner performance, for example) would be useful indicators.

These definitional problems are confounded in many situations by the fact that the organizations involved, as mentioned earlier, are unaware of the nature of their training functions and would seldom classify them according to the categorization outlined above. Gathering information on such activities may be extremely difficult except in the very large or very progressive enterprise where employee development is a recognized, differentiated activity. There are two possible attitudes that one may take to this situation. The first, phrased colloquially, is "that if they don't know they're doing it, they ain't." R&D is usually conceived of as a consciously planned problem solving process; the structure is a useful guide to follow in deciding whether R&D is occurring, except where it is occurring and the organization uses some implicit differentiation between "education" and "training" to exclude it from consideration as educational R&D. The second attitude is based upon the converse: "If it's not being done, it probably should be." There are many situations in which important educational needs exist but are unrecognized; there may be, objectively, an unmet need which, with some change in circumstance, will be recognized and dealt with through R&D. Between the two attitudes there is a gap in definition of what the R&D system might include: it is the supply or production of R&D, then the first attitude should prevail; if it is the demand or need for R&D, then the second attitude seems more appropriate. We shall return to this problem in the of the paper as part of a discussion of what is meant by a market for R&D.

B. MEDIA AND MESSAGE SYSTEM

The knowledge creation and utilization process described in the previous section is dependent for its operation upon the existence of a communications capability; in our society this capability is dependent upon an important technological infrastructure. Although the communications infrastructure overlaps in large measure with the knowledge creation and utilization process, it is not exactly congruent with it, and the analysis of specific media and message systems provides a somewhat different dimension of study. The expansion can be symbolized by the addition of a fourth circle to the Venn diagram used earlier:

Insert Figure 17 about here

We shall discuss briefly two potential ways of using this concept for expanding the R&D system: (1) analyzing media production and delivery systems in the sense of a raw delivery capability for the medium and then (2) isolating specific major media systems of importance for educational R&D.

1. Media production and delivery systems

In discussing media production and delivery systems, we refer both to the production and delivery facilities, in the sense of

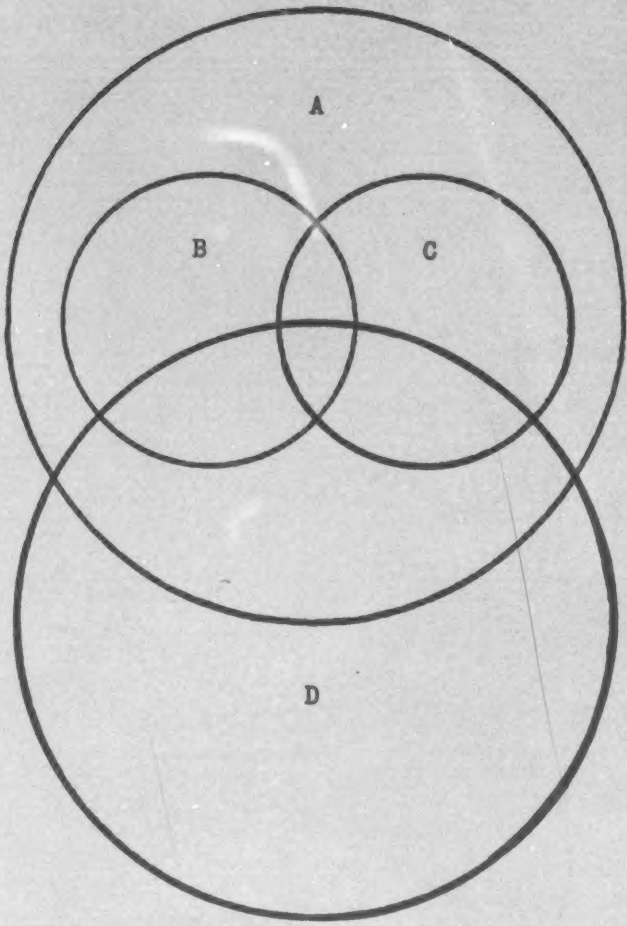


Figure 17.

equipment, and to the persons or organizations employed in operating the equipment. For convenience, it is perhaps best to discuss separately telecommunications media and other media. The two can be employed jointly on the same educational task, but at present they are generally organized separately in this country.

The potential of radio and television for educational purposes is much talked about but less frequently applied. It should be clear from experiments like Sesame Street that it is possible to design their content in a rigorous, carefully evaluated framework that fits under most definitions of educational R&D. The problem is, therefore, not whether to include these media and the related infrastructure in our expanded definition of the educational R&D system. It is rather to decide what portions of the total infrastructure of the country do not fit within it. Broadcast television constitutes a major portion of the nation's total cultural environment, one which impinges upon nearly every household. In addition, the standards applied for the design of programs are rigorous in the extreme, at least as regards their media envelope. Yet, even by the most broad standards of educational intent, the majority of commercially broadcast programs do not constitute educational television. For practical purposes, therefore, it is necessary to develop a criterion of exclusion: "Educational" television and "educational" radio should be included as part of the educational R&D infrastructure; generally speaking, these concepts will not include the preparation or distribution of programs intended primarily to serve as entertainment, defined as dramatization of fictional events, or primarily to facilitate delivery of commercial marketing messages.

Although not usually thought of as part of telecommunications media because most current use is geographically limited, computer assisted instruction systems should also be considered in the definition of message systems used for educational R&D. The only definitional problem involved in this respect is the need to exclude routine administrative use of computers. Although many communication networks have been built up for such administrative purposes and are, potentially, applicable to educational use, the only ones what should be included as part of the R&D infrastructure are those which have been effectively used for this purpose for a certain period of time. The program production capability associated with such systems would be subject to the same criteria as other types of educational R&D; individual teacher usage of these systems in the absence of systematic procedures for program development would be excluded by most definitions.

When one turns to the question of media production capability for media not distributed via telecommunications, similar problems arise. The educational textbook industry is the major factor currently affecting the content of teaching in our educational system. The print medium is definitely "in" our expanded concept of the R&D system; the question is which part of it should be excluded. (It should be noted in passing that most commercial publishers of educational materials provide a range of non-print materials in the form of films, slides, etc.; these are understood to be included in this discussion). The whole fiction publishing industry might qualify under one definition, since there is obviously a lot of fiction having literary or educational merit; the general production and distribution of factual information in any substantive domain is also potentially "educational"

The only solution appears to be to begin with a very narrow definition and expand it only the amount necessary for practical purposes. Publishing activities directed toward the public education system and persons studying in it, should qualify; so, also, should publishing aimed at providing the individual learner with carefully structured self-instructional materials marketed on the basis of their educational value. (A detailed taxonomy would be required for any specific application of these criteria).

What portions of this media production system, so defined, constitute R&D in a rigorous sense is subject to question. The publishing industry provides a great, but unrealized, potential for systematic R&D. This potential exists despite the fact that most of the textbook publishing industry uses artisanal methods comparable to cottage industry in the general manufacturing domain. To be more precise, the physical manufacturing of textbooks and other teaching aids is organized using the latest industrial methods. However, the quality control involved is exercised mainly over the medium itself: quality of graphic designs, typography, grammar and syntax of text. Only minimal standards are applied to the content itself, at least as regards the impact on the learner. In summary, when one includes non-telecommunications media in the definition of the R&D system, only that part which is directed toward structured, formalized educational experiences should be included. Since even that portion is generally somewhat removed from the concept of systematic research and development, its inclusion is justified only in terms of its potential rather than its accomplishments.

2. Specialized information systems

The author is unaware of any taxonomy which adequately categorizes all types of information systems, as these span the whole range of potential human activities. For want of a better taxonomy, the discussion that follows will be based upon a rough distinction between (1) public-access systems and (2) transformation usage systems. The first set of systems are those which are intended to provide access to information for a general class of users, such as the public in general (libraries), university biochemistry researchers (a scientific abstract service), etc. The second set of systems is generally those which are intended to transform knowledge into forms useful for solving specific problems. The distinction cannot be made always, but it adequately serves to categorize most relevant systems.

The only way that I can visualize for developing a list of information systems suitable for inclusion in an educational R&D system is to begin with a definition of user publics and work backwards, determining whence they obtain their information and then deciding upon the relevance of the systems involved. Since such a study is obviously not possible within this paper, I propose to limit myself to a few general remarks.

Out of the whole vast domain of public access information systems, any likely monitoring system will have to be extremely limited in its choice. In all likelihood, the main systems to be considered initially are those which receive state support, such as the public library system and public information systems of federal agencies for the public at large in the informal/education sector; selected professional publications for educators in the task-oriented education sector; and, for the public education system, a somewhat larger selection of systems. Of the information networks serving the public education system, one should definitely include the Educational Resources Information Center (ERIC) system, professional education journals and systems intended to assist the in-service training of teachers and administrators. The ERIC system, which dwarfs in size any other educational information system, has two characteristics which should be mentioned: (1) It should not be conceived of as an entity limited to the data base and processing system (clearinghouses, production facilities, etc.) supported by the U.S. government; it is the "front end" of a much larger information system, an enormous scientific and popular press infrastructure which is, of itself, a part of an expand educational R&D system concept. (2) The facilities provided within the system include, at least on a limited basis, functions which are close to those described below as part of transformation and utilization systems: query negotiation, search, retrieval and transformation (synthesis, analysis and interpretation).

Because of their relatively large influence but limited numbers, professional, full-time R&D personnel (narrowly defined) constitute a public whose needs deserve to be studied carefully on a regular basis. Although they are among the prime users of formalized information systems such as ERIC, it is clear from the history of scientific discoveries and the general lore on how personal decision-making operates, that the study and development of information systems for this group of people must also include informal communication (and prestige) networks.

An obvious point to be made about public access information systems is that the whole formalized educational process in the public school system is the largest information system in the category. For obvious reasons, it is not included per se in the educational R&D system but certain aspects of it should be, particularly the formal education of educators.

By information transformation and usage systems, I am referring to a broad class of mechanisms by which users of information transform it in order to adapt it to their own needs. A straightforward example of such a system might be the way that a school district obtains information on, say, demographic conditions in the area and joins it with other information regarding current resources to predict potential shortages of classrooms. In general, these systems encompass the whole range of processes by which information is treated for the purposes of decision-making and action. The level of analysis can range from the very broad (e.g. legislative decision-making) to the level of the individual. From the point of view of an educational R&D system it is extremely important that these systems be included, particularly at the level of the operating educational management and implementation unit, the school district and the school, for the K-12 system.

The study of information transformation and usage systems in education is still an art in its infancy. Almost intractable problems arise from the complexity of the data available. Formally established mechanisms for processing and using information are frequently overriden, in terms of influence on actions, by informal interpersonal chains of information, whose analysis may require methods derived from psychology, anthropology and information science. Though monitoring on a continuing basis is a patent impossibility, these information systems and chains of decision-making are at the very heart of the whole question of whether educational R&D is an effective method for introducing beneficial change into any aspect of education. They are deserving of study in order to determine how existing systems work (as opposed to how they are said to work). Development of prototype systems working more effectively (however defined) than current ones constitutes, or should constitute, a recognized branch of R&D activity. It may well be that the institutionalization of systematic transformation-utilization systems within existing "user" organizations for R&D will prove the basis for a different conception of R&D as applied to social problems, a conception more powerful in its implications for change than a massively subsidized, industrialized R&D having its institutional base separate from the "user" system.

The case has been made for including information transformation and utilization systems in an expanded model of educational R&D, at least from the point of view of potential. The practical problem is turning that potential into a reality.

C. RESOURCES

In this section we shift our framework of discussion to consider the educational R&D system as an economic activity requiring resource inputs. The means by which those resource inputs are created and allocated do not constitute educational R&D by any definition, yet it is clear that the whole enterprise cannot survive without them. Unless they are included in the expanded system, it will not be possible to explain adequately crucial aspects of its operation.

Three types of resource are of importance for R&D viewed as an economic sector: people, money and equipment. Although financial investment, or money, can usually 'buy' the other resources of people and equipment, at any one point in time there are factors which mean that these different classes of resources are not immediately interchangeable: Money to pay salaries, for example, cannot remedy a lack of highly trained research staff in a frontier discipline. It is this scarcity property of resources (including money) from which derives their interest for policy-making and analysis. Separating them out as individual items for study does not imply that they do not interact; quite the contrary, none is conceivable without the others. The discussion below presents relatively simple descriptive models of resource input flows to R&D activities, they are subject to elaboration (that is, through introduction of greater levels of detail either by subdivision of the elements in them or addition of new elements) but suffice for extending the concept of system boundaries.

1. Manpower

The term "manpower" is preferred in discussing the first flow because it is traditionally associated with discussion of people as factors of production in economic life. The major elements of scarcity are associated with two characteristics of manpower: (1) availability in terms of numbers and (2) skills in relationship to work to be performed. In terms of the R&D system it is important to note that we are not dealing with manpower solely as a production factor; Consumption of goods and services created by R&D processes requires that the consumer possess specific skills. To take a simple example, not always perceived by persons responsible for purchasing decisions in school systems, the introduction of new media such as language laboratories into teaching practice requires that the teaching staff have skills not demanded in the usual classroom (not to mention the other users, the students).

When manpower supply is modelled in terms of the two scarcity factors mentioned above, it is usually in terms of transition through a training or educational system, where passing through the system is equated with acquisition of required skills. Let us examine the model type before dealing with its shortcomings. These models are based upon an "input" of students and an "output" of graduates; at each point of transition through the training system, e.g. at the end of grades in a grade-promotion system, one takes a measure of how many go on to the next phase, "passers", how many go back and repeat the training experience, "repeaters," and how many have left the training system altogether, "leavers." The following schema illustrates how a graph of such a system flow might be drawn to show the transition relationships:

Insert Figure 18 about here

In this hypothetical example, the nodes numbered 7,8 and 9 might be the grades in a junior high school. One might suppose that the school intake in a given year is 100 students into grade 7; of these 3 become leavers during the year and 10 repeat the following year, so that, of the original 100, only 87 (100-10-3=87) go on to grade 8. (In the diagram, the values would be $r_7=10$, $l_7=3$, $o_7=87$). The only complication in this calculation results from the fact that the total intake in grade 7 includes both new intake of 100 students plus the repeaters from the previous year. If these proportions were the same in the example for two successive years, the second year input to grade 7 would be 110 (100+10), the repeaters would be 11 (10% of 110), the leavers (theoretically) 3.3 (3% of 110) and the passers 95.7 (8% of 110): This illustrates the mechanism for calculating a prediction of throughput based on stable inputs and stable transition

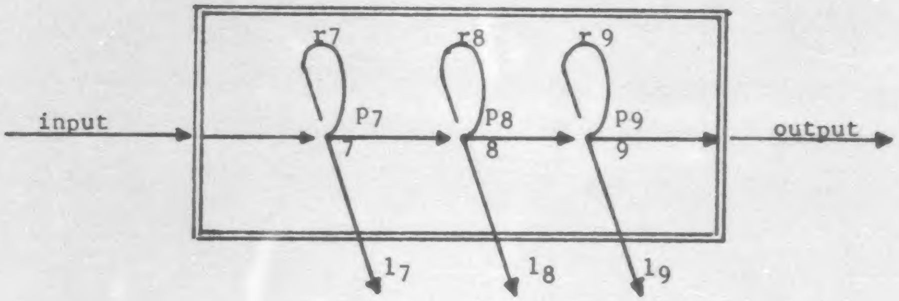

r7
r8
r9
input
P7
7
P8
8
P9
9
output
l7
l8
l9

Figure 18. Hypothetical flow model illustrating principle of transition through a graded educational structure

factors; in practice, inputs vary and transition factors vary, and living students either pass, repeat or fail in integral numbers.

The principle of such a flow model is very simple, which explains its utility for such purposes as predicting enrollment figures, particularly for large population aggregations where local disturbances can be ignored in arriving at over-all patterns. For the purposes of modelling the R&D system, the model has important shortcomings, deriving from underlying assumptions. Specifically, movement through such a system is based upon some screening mechanism, such as a test, which is not necessarily a good measure of the skills supposed to be taught; the test may be unreliable and/or invalid, and its application may be completely biased by circumstances (e.g. teachers' negative attitudes towards certain students might result in a measurable, "true" decline in performance on an otherwise reliable test). Whether one is discussing a single test or a whole process of certification in which a certificate, degree or diploma is granted, the principle remains the same: the criterion for passage through the system is not necessarily correlated with the intended content of the teaching system. This principle has a sort of multiplying effect when applied to the second assumption, namely that the intended content of the teaching system is really related to a job-skill (to limit ourselves solely to this educational output for the present discussions). A final complication results from the structure of the systems usually modelled, namely that one level follows sequentially from the other in a necessary relationship: "You can't go to ninth grade until you pass the eighth." The model describes the way in which the system actually operates, thereby showing the poor fit between most sequential teaching systems and the actual process of learning. These shortcomings are carried over into larger models of manpower training systems and manpower placement systems, which will be discussed next.

The diagram which follows is an illustration of some of the major elements which should be included in a model of a skilled manpower supply system. For purposes of illustration, the model is divided into two major sections, the primary specialized training system and a job activity system involving training functions. Persons entering or leaving the systems are presumed to enter the general pool of manpower which may be considered to be roughly equivalent to the active or potentially active population at a given time. When tracing the actual experiences of persons with a given type of skill or when looking at the history of a single individual, it is clear that (1) no part of the system elements can be considered to apply to all cases and (2) additional elements may intervene. Above all, the arrangement of the "flow" is not intended to suggest linearity, in that most movements of individual persons are presumed to be mediated through the general manpower pool; job recruitment at any phase of a person's career is not presumed to require his having passed through the primary specialized training system; there is no presumed necessary relationship of training to skill or of skills and training to recruitment.

Insert Figure 19 about here

Figure 19. Simplified diagram of flows in a skilled manpower system

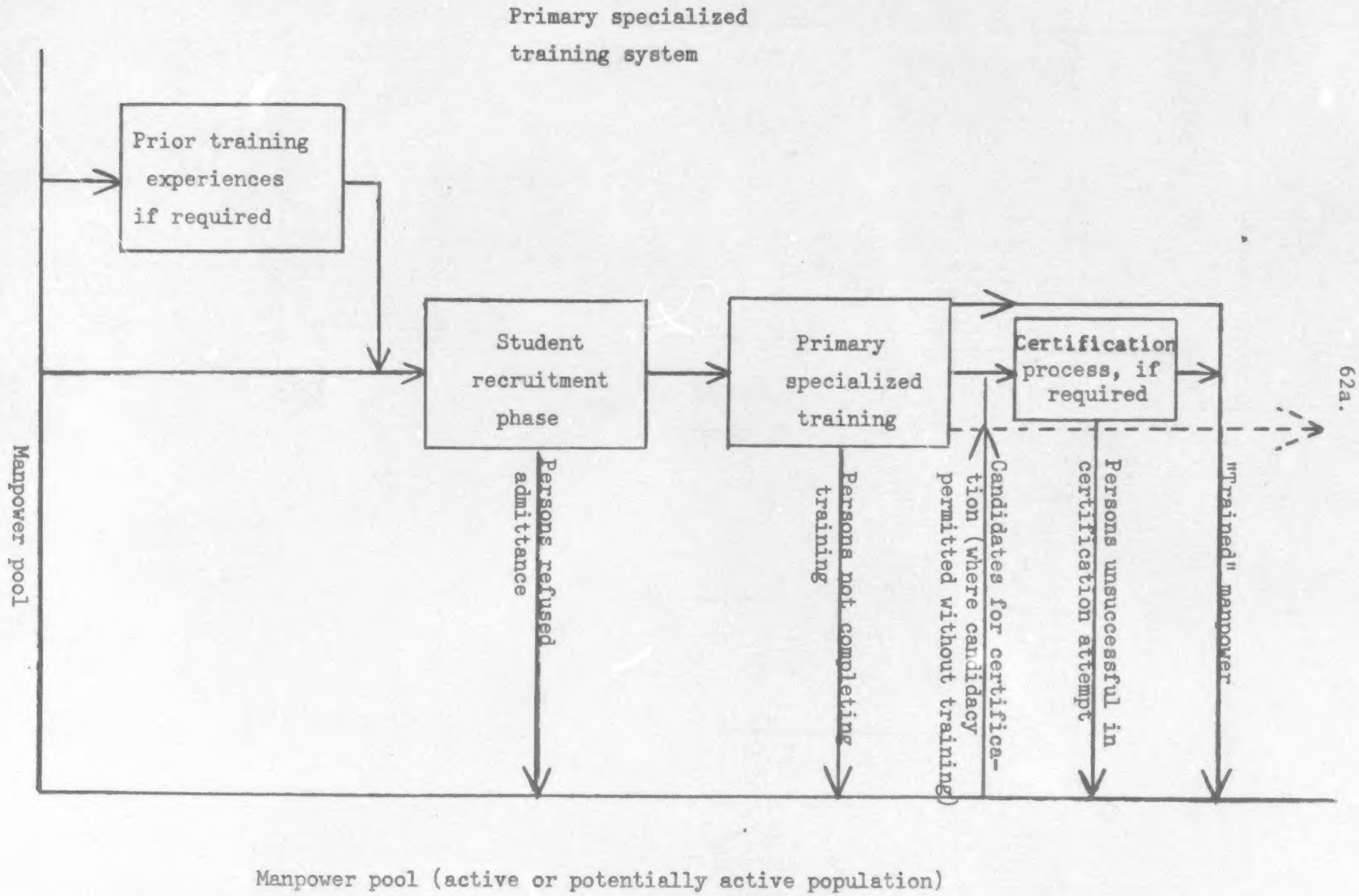
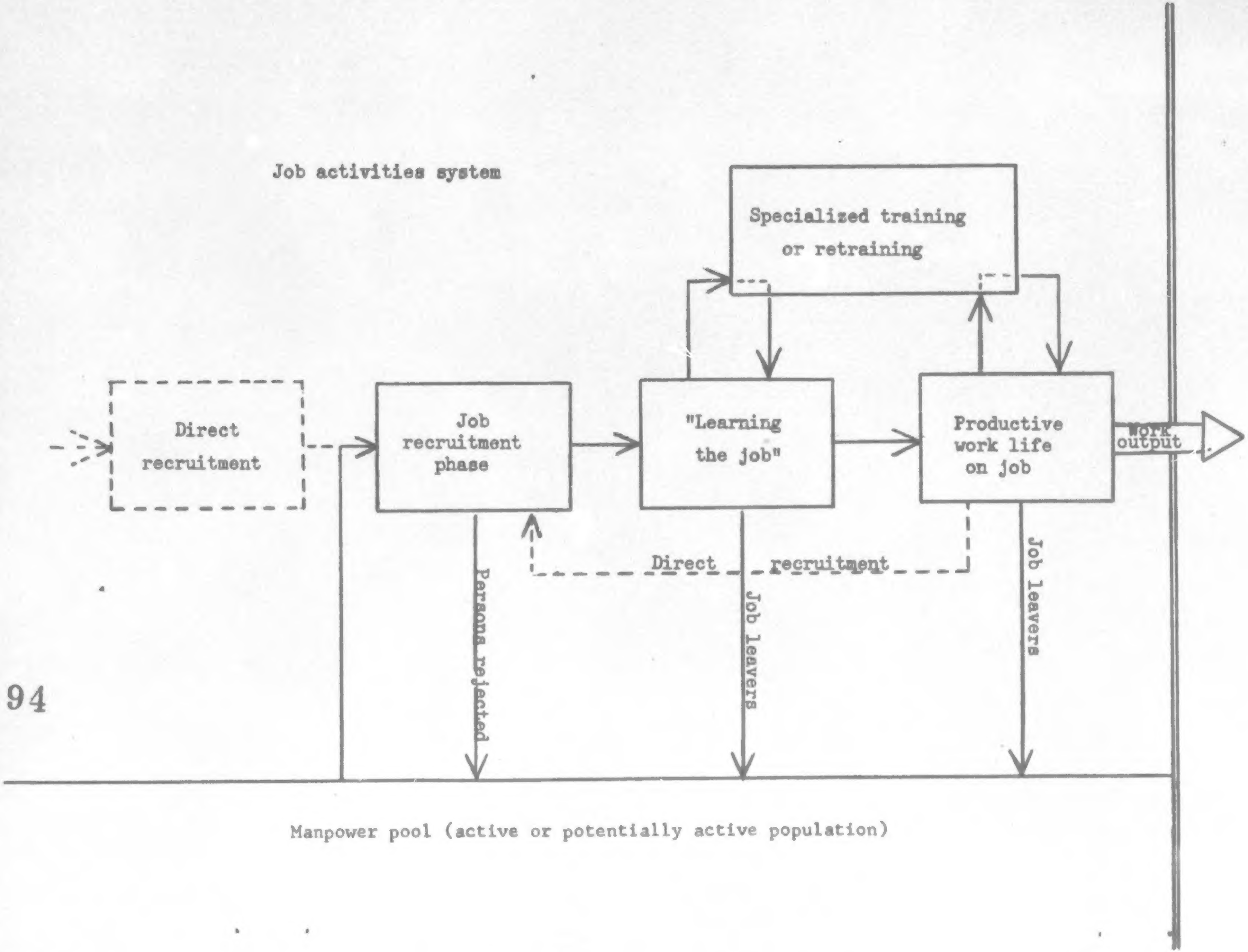

Primary specialized training system
Prior training experiences if required
Student recruitment phase
Primary specialized training
Certification process, if required
Manpower pool
Persons refused admittance
Persons not completing training
Candidates for certification (where candidacy permitted without training)
Persons unsuccessful in certification attempt
"Trained" manpower
Manpower pool (active or potentially active population)

Figure 19. Simplified diagram of flows in a skilled manpower system (CONTINUED)


Job activities system
Specialized training or retraining
Direct recruitment
Job recruitment phase
"Learning the job"
Productive work life on job
Work output
Persons rejected
Direct recruitment
Job leavers
Job leavers
Manpower pool (active or potentially active population)

The major benefit of visualizing the manpower flow as a unified whole is that it serves to point out common incorrect assumptions which, if noticed, are seldom incurred. These might be summarized in point form:

1. The notions of "supply" and "demand" are exactly inverse, depending upon the point of view. Decisions about setting up new training programs are frequently based upon a projection of student "demand"; this "demand" depends in part upon the "supply" of student places available. Conversely, a lack of trained manpower in portions of the job activities system generates a "demand" for persons which presumably can only be satisfied by an increase in "supply" of students. The important point to derive from these truisms is that there is no easily predictable link between the two types of demand/supply. Increasing training opportunities may not increase even the number of recruits entering the training system, much less guarantee a flow of job applicants.
2. The indirect relationship between the two systems and the considerable delays involved in most kinds of primary specialized training indicate the necessity of avoiding decisions affecting either system without careful consideration of how delays and subsystem autonomy affect the assumptions underlying the decisions.
3. The items in the job activities system labelled "learning the job" and "additional specialized training or retraining" are introduced in order to emphasize the following points:

   -That training prior to a job is seldom sufficient in itself and usually requires to be supplemented immediately after recruitment.

-That under ordinary conditions of technological change, many types of factual knowledge have a rapid obsolescence rate, requiring that retraining be considered a normal part of job life.

4. A separate flow called "work output" has been indicated to emphasize that recruitment into work and even holding a job are not good criteria, alone, for judging the success of a job oriented training program. In some areas, such as basic research, short-term productivity after initial training or retraining is hardly a worthwhile measure of effectiveness.

From the point of view of "expanding" the system boundaries, one has thus far succeeded in clarifying two issues:

1. The high degree of dependency between primary training and job activities together with the partial autonomy of each system means that definitions of either system are incomplete if they exclude the other system from consideration or proceed on the folkloric assumptions which are refuted by an integrated view.
2. Although only briefly alluded to in this discussion, any attempt to limit the manpower system definition to a consideration of "producers" of R&D, in the strict sense of researchers or product developers or whatever, is too limited a view. There is every reason to include the "consumer"

as well, particularly when assessing relative scarcity.

In view of the facts that scarcities are liable to appear in areas where change occurs rapidly and that these are the areas where obsolescence of prior learning is liable to be highest, an important new emphasis appears when studying manpower systems:

3. On-the-job or in-service training systems, including generally learning during work experience, should be specifically included in virtually every systematic study of the R&D manpower system. In particular an effort should be made to incorporate, wherever possible, the element of individual, self-directed learning experiences. There are strong indications in the research literature that long-term output (as well as short-term success) may be related to individual learning patterns and socialization experiences far more than to the variables usually considered in drawing up policy options or models related to them.

2. Finance

The model of a financial flow is extremely simple and familiar to all. a gives money to z, who allocates it to several uses m, n and p:

Insert Figure 20 about here

In other words, money "circulates" over a period of time, and the

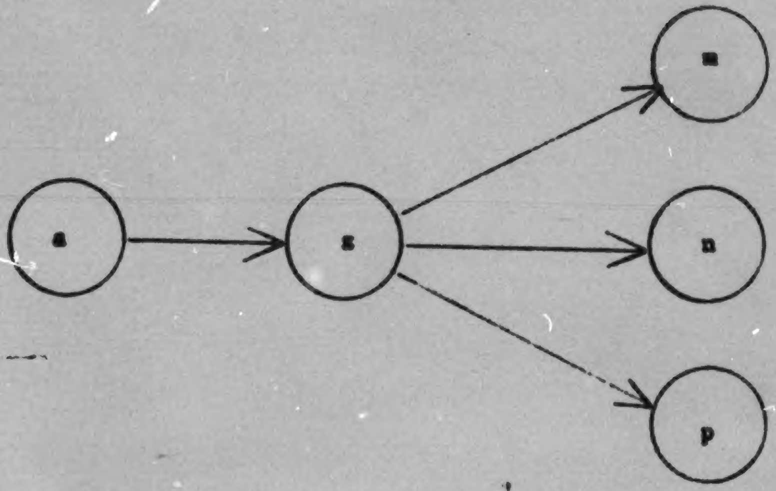


Figure 20. Illustration of principle of financial flow

circulation can be traced as a flow. In the field of R&D one might visualize a department of government such as the NIE allocating funds to a R&D laboratory, which uses the funds to buy services of research personnel and the necessary equipment and other facilities required to carry out activities over a period of time. Generally speaking, monetary flows generate associated 'activities' as well as further financial flows:

Insert Figure 21 about here

A principal concern of most analyses of financial flows will be to determine the relationship between monetary inputs and activity outputs. And, in most cases, the analysis will deal with the utilization of money by an institution such as a laboratory or a school system; but the principle should be kept in mind that the analysis technique can be applied at different levels of aggregation, ranging from the total outflow of money from the federal government to the revenues of the individual researcher.

In order to get at the major problems of financial flows in the R&D system, it will be necessary to look more closely at the juncture between financial inputs and activity outputs, which we shall call the "activity unit." The activity unit is any agent (i.e. organization of persons engaged in any phase of R&D activity down to the individual researcher, as defined earlier) involved in the R&D process. Viewed from the point of view of the activity unit, the funding cycle for R&D activities might be schematized as follows:

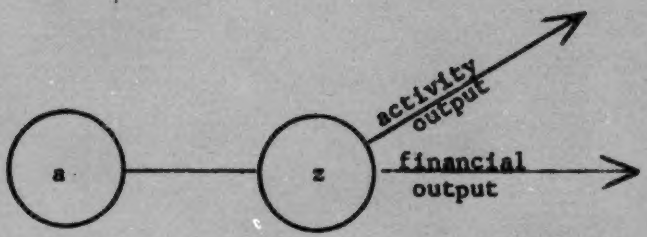

a
z
activity output
financial output

Figure 21. Illustration of principle of financial input giving rise to financial flow and related activity output.

Insert Figure 22 about here

The choice of inputs and outputs is intended to point out several important facts about the funding and costing of R&D activities: (1) Only a few organizations involved in it are exclusively dedicated to carrying out R&D; funding for R&D ordinarily constitutes only one source of revenue, not necessarily an important one. (2) Even in organizations dedicated to carrying out an R&D function, there are numerous expenditures which are not directly related to an R&D activity; in multi-purpose organizations such as universities, expenditure on non-R&D activities is frequently much greater than the direct expenditures. (3) A significant factor in many R&D activities is the existence of an organizational base, the result of previous expenditures.

These facts become of great significance when it is understood that the typical funding picture of many R&D activity units involves several funding sources, each with different objectives. The way in which funding decisions of different agencies interact is very poorly charted but is obviously not to be overlooked. As an example, one might think of a typical state university, deriving most of its revenues from the state government; the state funds are understood to be underwriting a portion of faculty research, considered to

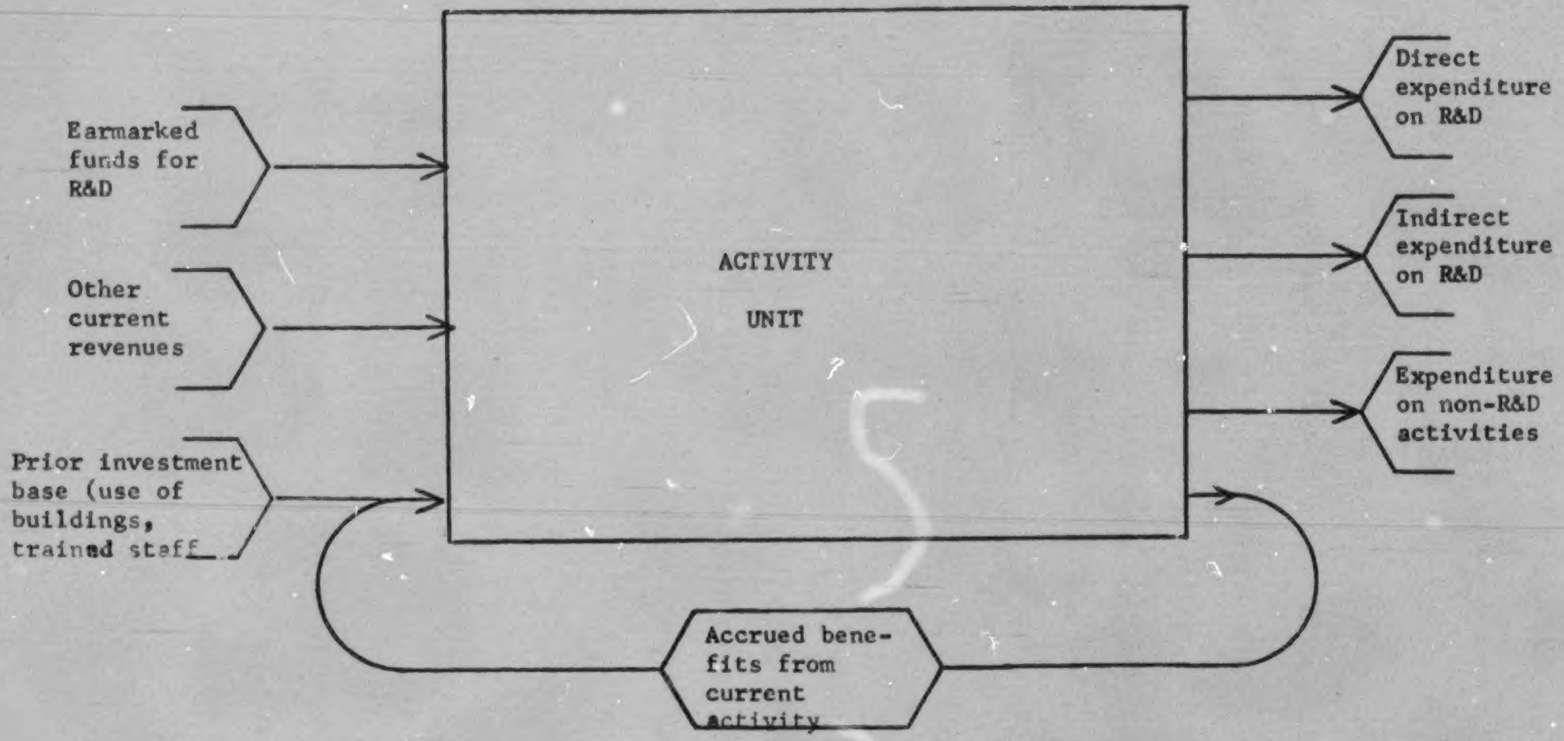

Earmarked funds for R&D
Other current revenues
Prior investment base (use of buildings, trained staff
ACTIVITY UNIT
Direct expenditure on R&D
Indirect expenditure on R&D
Expenditure on non-R&D activities
Accrued benefits from current activity

Figure 22. A simplified revenue/cost model for an R&D activity unit.

be a basic part of the teaching process. The university might be receiving a special grant to improve teacher training programs, as a consequence of which the faculty of the education-related teaching departments have been considerably expanded. In a given year these same departments receive special grants totalling, say, $100,000. If the individual grants are relatively small, say in the $10,000-20,000 range, an accurate costing of expenditure on R&D activities might reveal that the total outlay is more than $200,000, with the cost of faculty salaries being greater than the grant money received. The following year the agency giving the grant for the teacher education programs may decide not to renew the grant, representing a revenue loss for the university of, say, $200,000. At the same time, the R&D granting agency might decide to double its grants, from $100,000 to $200,000; the assumption might be that this would double the amount of R&D work done. In fact, the university would be receiving $100,000 less from these two grant sources. Given the complexities of institutional accounting, it would be rash to accept the assumption of a doubling of R&D activities, at least under normal circumstances. The purpose of the example is not, however, to illustrate how a university can arrange to keep a stable faculty in a time of shrinking revenues; it is to point out the fact that R&D granting agencies frequently pursue policies which, at best, are made with incomplete knowledge of other factors and, at worst, are rendered ineffectual by other factors. The example further illustrates the role played by the existing organizational base: A significant decline in the amounts of money available for faculty salaries combined with a constant or rising teaching load would have a long-term effect on the output to be expected from a given R&D financial input.

This flow model of the financial system for R&D can be a useful tool in conceptualizing an 'expanded' national R&D system. The following points can be made:

(1) Inspection of the example given above has demonstrated clearly the interaction effect between different sources of revenue reaching an R&D activity unit. It points out the fallacy of considering funds specifically marked for educational R&D as the sole component of the system of resources supporting educational R&D. An expanded model should, if possible, account for other financial resources whose use is significant in the R&D effort.

(2) The model of an activity unit was illustrated by the example of an R&D 'producer', a research organization. The model is even more useful when attempting to come to grips with the problems of the R&D 'consumer'. The costs of R&D 'product consumption' have seldom been considered in financial planning; they are obviously a major component of the R&D system, though relatively unknown.

(3) There is no implication that the R&D activity unit is necessarily institutionally separate from the funding source or the consumer of the R&D outputs. If a school system invests in its own research and development activities, it can be simultaneously funder, producer and consumer. The same obviously applies to businesses that systematically develop training programs for their own employees. Such 'internally consumed' R&D is part of the R&D system, and the financial flows associated with it are important to understand.

The concept of a financial flow does not stand in isolation from other aspects of the system. The activity unit above has been visualized merely in the abstract as a "black box"; in practice, we are dealing with different levels of complex societal organization with widely varying degrees of internal functional specialization. The relationship between the financial inputs and outputs is not fixed but dynamic in any given organization; and no two activity units are likely to have precisely similar patterns of behavior. It is possible to systematize and study organizational behavior from many points of view. In the case of the financial flow, the specific behavior of importance is what one could call an "allocation process" and this process should be considered part of the R&D system. In terms of the categorizations suggested in the section on terminology, the allocation process is in the category of regulators and can best be understood in relation to other regulators, which will be described below. For the present it suffices to point out that the agent, or activity unit, involved can be considered to be at the juncture of two separate flows, as illustrated by the figure below:

Insert Figure 23 about here

3. Equipment

The concept of 'equipment' in the sense of material goods used for research and development activities, hardly needs elaboration. In fact, for many types of research and development in education, it can frequently be taken

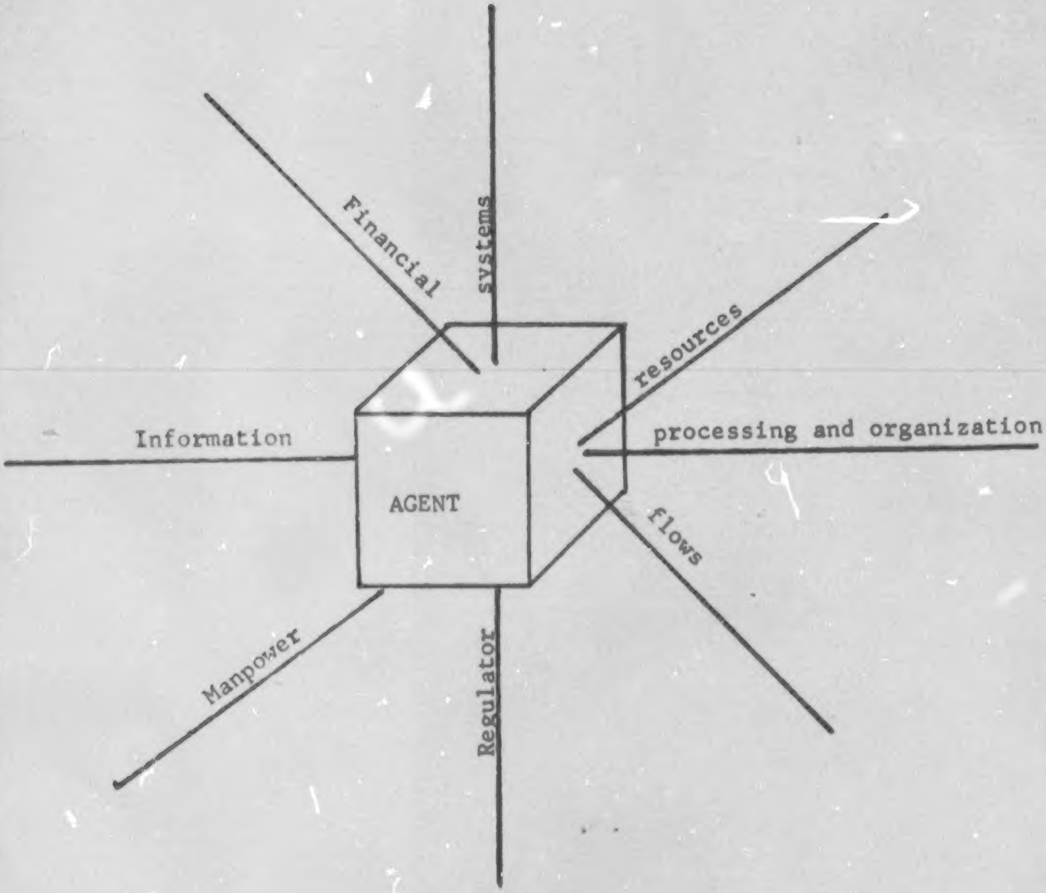

Financial
systems
resources
Information
processing and organization
AGENT
flows
Manpower
Regulator

Figure 24. Illustration of concept of agent as juncture between different subsystems

for granted. Except in setting up new institutions or organizations, one can ordinarily count on the availability of buildings and laboratory equipment; where they do not exist they can be acquired easily. The enormous capacity of the installed technical infrastructure of the United States renders many types of equipment nearly interchangeable with money as a factor of production or consumption. (This is always relative. To convince oneself of the truth of the assertion, it suffices to compare the situation of the United States with the opposite extreme of certain developing countries which lack the productive infrastructure to produce the materials to build buildings and where project planning for research requires one to foresee things like ordering filing cabinets from abroad months in advance of their usage).

There is little analytical interest in dwelling upon many types of equipment. Almost all the exceptions to this rule are in the field of new communications media: language laboratory installations in schools, television broadcasting stations for distribution of educational television programs, computing equipment and associated software. It is possible to trace a flow of equipment of this sort, just as it is for durable items of the national infrastructure like buildings: creation and acquisition, installation, maintenance, obsolescence and eventual removal from use. The flow, so defined, provides little insight into the processes of educational R&D in the United States. At most, one arrives at the concept of, perhaps, inventorying critical items where scarcity persists.

D. Regulator system

Merely defining the concept of 'regulators' is sufficient to broaden the concept of the national educational R&D system. In the conceptual framework proposed earlier, they were defined as "procedural conventions determining the activity of agents." Taking this definition as it stands, one can interpret it at the extreme to refer to the whole domain studied by the behavioral sciences, anything affecting human behavior either in the individual or collective sense. This is, in fact, one of the purposes of phrasing the concept so broadly, in order to show how the results of a whole range of research can eventually have a bearing upon the concept of a national R&D system. But once the point has been made, we must attempt to bring the concept back down to earth, so to speak. The term 'regulator' was chosen with the intent of conveying the prime criterion for selecting regulators for inclusion in the concept of the national R&D system: out of the whole possible range of individual and organizational behavioral systems and variables, one wishes to focus attention on those which have a regulatory function vis-a-vis of the other components included in the expanded system, such as the resource supply system or the knowledge creation and utilization system. The analyst of any component of either system will have as a major concern the definition of regulators affecting the object of his study; the possible variety is infinite, and only experience will show which are the most significant in what context. Since it is impossible to draw up an exhaustive list of regulators or, presumably, even to conceive an exhaustive taxonomy for their classification, I intend to discuss a few of the more significant aspects of regulators or regulator systems which should be kept in mind, and then to propose a number of types of regulator which appear to be of major significance in monitoring developments in the national R&D system on a national basis.

In general terms, whenever one discusses regulators or regulator systems, one may consider them from two perspectives: the regulator may be the product of a process by which the regulator is created and maintained, or it may be an input variable affecting some other system element, an input to a process. A concrete example of these aspects might be the allocation of resources to activities within a research laboratory: one might consider the way in which the decision-making process came into being (selection of participants, definition of their roles, origin of the rules of decision-making, environmental factors affecting the origin of the decision-making process and its operation, and so forth); or, accepting as a given the factors present at the time of any one decision or set of decisions, one can see how the decision-making structure operates to regulate the usage of resources. In the first instance, the regulator is viewed as the output of a process; in the second, the regulator is an input. Both processes are obviously interrelated and may eventually be studied as an integrated whole.*

In summary, then, regulators will be of interest which are significant inputs controlling portions of two processes: the provision and usage of resources for research and development, and the creation and utilization of knowledge in the R&D process proper. The regulators themselves are the outputs of processes which are a legitimate object of concern and study inasmuch as they are ultimately inputs to the R&D process: essentially, the agents (organizations or individuals) participating in the elaboration of regulators, the structures or processes by which regulators come into being, the value systems intervening (rules of individual or organizational conduct), power relationships, the general environment within which the whole operates (social and historical context). Under most circumstances it will be sufficient to describe the regulator and its functional characteristics without entering into consideration (except for scientific purposes) of its origins. A law governing expenditures by school districts, for example, is an explicit set of behavioral rules whose operation in a given context can probably be predicted within certain limits; it is seldom necessary to return to the legislative process by which the law was created in order to arrive at the prediction of its impact upon, say, the possibility of increased spending for language laboratories. The example illustrates the criterion mentioned earlier that our definition of system boundary will depend upon our estimate of the degree to which the regulator's operation constitutes a regulatory function vis-a-vis of the R&D process.

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*This double perspective is useful in that it permits one to eliminate the artificial dichotomy of descriptive and prescriptive models: Prescriptive models are, essentially, constructs employed to guide behavior, that is to regulate individual or group conduct; descriptive models are a different type of behavioral guide. Their impact on behavior, whether direct or mediated, is similarly dependent upon circumstances.

The remarks above suggest the dimensions of eventual studies of regulators. I propose below a number of regulators or regulatory systems which are of sufficient interest, in my opinion, to be included in their own right as components in the national R&D system. They vary considerably as regards the degree to which they have been formalized; all are chosen for their relationship to the making of policy at the national level and its implementation. In each case it should be clearly understood that I am referring only to those aspects of a topic which are directly relevant to the R&D process.

(1) Statutory law at the state or federal level affecting the conduct of R&D, including the process of adoption and implementation

(2) The decision-making structures and processes of federal agencies sponsoring educational R&D, particularly the National Institute of Education

(3) Management techniques for R&D conceived in the broadest sense, specifically those applied:

(3.1) -by major funding sources of R&D activities

(3.2) -by major institutions carrying out R&D project work under external funding

and, as special cases, two inputs to the process of elaborating management techniques:

(3.3) -proposed models of the R&D process including specialized taxonomies of activities and roles assigned to individuals or organizations

(3.4) -alternative models of educational "futures", i.e. conceptions of what education "might or should be like" (utopian) or what it "is likely to be" (predictive)

(4) The administrative systems and policies of state and local education agencies with specific attention to:

-the process of planning for change in the agency itself, including the definition of new goals

-the adoption and implementation of R&D products (ideas, techniques, material products)

-participation in the generation of R&D products at any phase of the process: setting goals, defining means, implementing the chosen means, evaluating the outcomes

-the categories of participants either formally or informally associated with these processes (administrators, teachers, students, parents community/special minority, etc.)

(5) The practices of major professional groups (teacher organizations, educational administrators, professional researchers) including the value systems and socialization processes underlying the maintenance and evolution of the practices

(6) The "market" for educational R&D conceived as a supply-demand mechanism for process regulation.

It should go with out saying that the above list can be (1) extended to include other regulators, (2) subdivided to give attention to particularly important regulators, or (3) incorporated into one or more taxonomies of a more general nature. As far as possible, the list is composed of specifics ---regulators which have an intuitively tangible content. There are three exceptions in the nature of special cases, item 3.3 (R&D models), 3.4 (alternative futures) and 6 (market). The inclusion of models of R&D and alternative educational futures under the heading of "input to the process of elaborating management techniques" is defensible only as being one of the more important reasons for theorizing about R&D, not as the sole purpose to which such models can be put. Whether they are grouped in this way or not, such models and model-building activities have a special place in the scheme of a national R&D system, in that they are both products of its development and guides to the future orientations which it will take. As mentioned above, many of these models define taxonomies of procesees, functions and goals which are intended to be of potential value in organizing and improving the efficiency of the R&D process.

Reference to a "market" for R&D under the category of regulators is based on a similar observation of one characteristics of the "market," as a regulatory mechanism mediating between supply and demand factors. Because of the complexity of the concepts involved, it will be discussed separately in the next section of this paper.

Section 3. A Reporting Framework for Monitoring the Educational R&D System

A. WHY A FRAMEWORK?

The previous section has led us to explore in an intuitive fashion the many facets of activity which might be considered relevant to the definition of an educational R&D system. One need only think briefly about the whole to feel awed by its complexity. That complexity is increased, not decreased, by the multitude of different techniques which exist for the study and analysis of its different parts. A school may well be a node in a communication network, the object of a decision on expenditure, a sociological milieu having defined characteristics, a place where a certain curriculum is taught or an environment in which children learn things. (These last two are not, of course, synonymous). Academic experts specialized in information systems, economics, sociology, curriculum design or child psychology will see the school in every different ways, though all probably share some of the common attitudes which are supposed to characterize the scientific community. Differences in discipline or specialization fragment the scientific community just as differences in personality, social station and role tend to diversify the viewpoint of the public at large. On a grander scale what is true of the school is true of the vast entity we have called a national educational R&D system.

This diversity is at the heart of the problem of creating a monitoring system that is capable of carrying out the objectives specified in the introduction. On the one hand, information on the national educational R&D system is available in numerous forms, having been gathered by persons with very different purposes and techniques. On the other, the data must be conveyed to a variety of users. The rationale used to reconcile the contradiction is based on an approach that might be likened to Russian dolls.

A broad framework* is proposed, the outline of which is relatively simple to grasp. When its individual components are opened up, they are consistent both with the over-all outline and with the discipline bases required for monitoring and research on the R&D system.

The limitations of the approach are not negligeable. First, the generality of the framework is such that, in order to come to grips with many concrete monitoring problems, it will be necessary to introduce more specificity. Secondly, one can postulate safely that there is no way of providing all relevant information in a fashion that is understandable for even a major fraction of the persons who legitimately have right of access to that information. We are not likely to reconcile completely the information requirements of the laboratory researcher, the educational administrator and the concerned parent. The best success that can be hoped for is to structure a major part of the information in a fashion understandable by a major portion of the potential audience. In this way interested persons can delve into the information base to the depth required for their personal concerns and eventually engage in meaningful dialogue as participants in the process of democratic decision-making on science policy.

B. THE BROAD OUTLINE

1. Organizing principles

The reporting framework is based upon a few simple principles of organization, some so simple that they will frequently not have to be stated. For the purposes of clarity, the major assumptions underlying the framework are summarized here:

a. System definition. The definition of the areas covered by the framework depends upon the concept of educational "sector", that is, upon the specification of a set of users of R&D outputs. In Section 2, we have defined three broad educational sectors: public, task-oriented and informal.

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* The term "framework" has been used instead of "model" in order to emphasize the intent of making the framework broad enough to accommodate alternative "models" of the R&D process.

Though there are other ways of dividing up the educational spectrum, these three sectors are useful as examples. Beginning with one of them as the target population for utilization of R&D outputs, it is possible to analyze and identify the components of the system of R&D which is relevant. Subject to some overlap, the three sectors yield three different definitions of an educational R&D system; the R&D systems serving the three, when combined, constitute the total national educational R&D system.
Beginning with other definitions of educational sectors, either broader or narrower, yields different definitions of the R&D system to which the reporting framework is applicable. The principle remains the same: when using the reporting framework to describe an educational R&D system, it is necessary to specify the sector to which it is applicable. (Failure to proceed in this manner results in the definition of more limited sub-systems; for example, one could begin by identifying a body of researchers and then determining whom they serve, a procedure which would logically lead to leaving out of the system definition other potential, but neglected, users of R&D outputs).

b. Distinction between producer, process and product. In describing a factory which transforms raw materials into finished products, it is possible to distinguish between the tangible elements constituting the factors of production (buildings, machines, employees), the activities which are engaged in by these factors of production and, finally, the raw material in various stages of refinement and transformation. The distinctions are harder to draw in the field of R&D, owing to the fact that the product escapes most attempts at definition.

The distinctions are sufficiently understood that they have been used in organizing the elements of the reporting framework.

c. Inclusion of resource flows. It is, of course, quite possible to discuss an R&D system solely in terms of the persons, institutions and facilities actively engaged in either the process of creation or use of R&D products. In a framework useful for policy-making purposes, it is essential to include not only the actual productive capacity but also the resource flows which make the activity possible.

d. Separating out regulators. Purely practical considerations have led to regulators being included in the framework as a separate element. The intricate network of written and unwritten rules which govern behavior of individuals and institutions is largely uncharted, and the methods used for studying this network are very diverse. Frequent reconceptualizations of major portions of this system of regulators are to be expected. Clarity dictated a sort of "modular" approach as a means of isolating a very obscure and confused area from the other major elements of the framework.

2. Elements of the framework

The relationship between the elements of the reporting framework is shown in Figure 25 . The symbols used in the figure are quite

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Insert Figure 25 about here

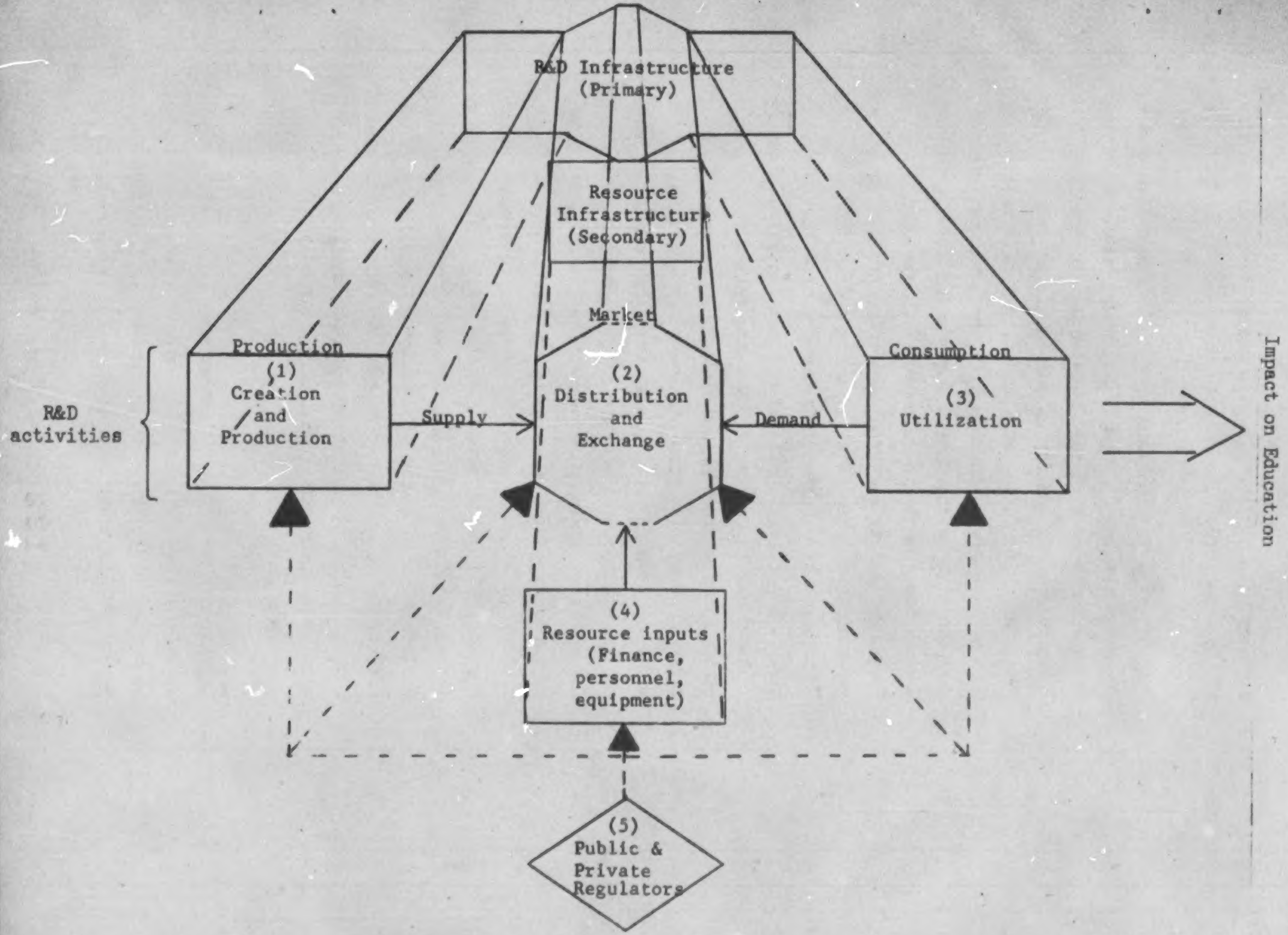
R&D Infrastructure (Primary)
Resource Infrastructure (Secondary)
Market
Production
(1) Creation and Production
R&D activities
Supply
(2) Distribution and Exchange
Demand
Consumption
(3) Utilization
Impact on Education
(4) Resource inputs (Finance, personnel, equipment)
(5) Public & Private Regulators

Figure 25. A reporting model for educational R&D

arbitrary; they have been used simply to give a distinctive shape to each major subsection of the framework. The components are as follows :

a. R&D Activities. The labels on the boxes are intended to cover the broad range of different models which have been associated with the "knowledge-into-practice" concept of R&D. As far as possible, the terms are kept "neutral". "Creation and production" of knowledge is not necessarily synonymous with the term "research", particularly in the narrow acceptation used by workers within the scientific community. "Distribution and exchange" can as easily characterize the concept of a communication network as it can the dissemination activities of a regional laboratory or a textbook publishing firm. "Utilization" may imply assimilating a new idea, installing a new language laboratory, or maintaining a planning and research department in a school board. The terms can be accepted at their face value as synonymous with most existing conceptualizations of the R&D process, whether this is conceived as "scientific knowledge into practice", problem solving, human interaction to innovate or what have you. Problems arise only when one is asked to specify which one of these conceptions is meant. All (and others) are intended. Further, in brackets next to the boxes, a different set of terms is associated with this continuum, corresponding to the terms used in dealing with the R&D process in the framework of economic analysis. These terms and their import will be discussed in detail further on.

b. Infrastructure. The R&D infrastructure is, broadly speaking, all those durable elements which make it possible to carry out the activities included in the creation/production/distribution/exchange-utilization continuum.

The major elements included in the R&D infrastructure are:

i. skilled personnel
ii. equipment (facilities, plant)
iii. institutions (or organizational structures)

Because many institutions and individual persons in the infrastructure carry out functions spanning the whole range of activities from creation to utilization, the infrastructure is portrayed in Figure 25 as a unitary whole, not necessarily divided along the functional lines of R&D activities.

It is important that this infrastructure be viewed as something broader than the sole creation/production function. There are many promising R&D products which have failed to be used for want of an infrastructure of utilization. For examples of this one need look no farther than Run Computer Run! (Oettinger 1969); this penetrating book is an almost caricatural portrayal of the inadequacies of current educational structures to cope with the fabled products of "educational technology".

c. Resources. The concept of resources is relatively straightforward. It comprises the furnishing of money, skilled personnel and material goods necessary for the R&D enterprise. Associated with this one can identify a second infrastructure of personnel, institutions and equipment necessary to provide the resources.

d. Regulators. Regulators have been defined as "procedural conventions, determining the activities of agents." Out of the multitude of factors affecting the behavior of persons and institutions, one ordinarily will select

> only a relatively small number to include within the framework at any one time. For initial explanation, the term can be considered synonymous with the process of political and administrative decision-making affecting R&D activities.

It appears to the author that a framework structured on these lines will be sufficient for explanatory and reporting purposes. In general public communication, the model can be used either with the infrastructure shown separately, or without it. Little or no explanation is required for any term other than "private and public regulators"; as stated above, these can be considered equivalent to the public control mechanisms exercised through the political process. At a later stage, one can make the generalization to include other types of regulator; in practice, for most reporting purposes, it may not be necessary to introduce the generalization at all. It is primarily useful for structuring rather specialized types of data and theories derived from research studies, such as the role played by diverse factors in the process of adoption of innovations.

With regard to the central concept of R&D activities, the neutrality of the terms used is intended to make it understandable by almost any public, independently of prior conceptions of how research is done, how ideas spread or how education changes. It can be illustrated easily by mapping into it the most commonly used divisions of R&D--- research, development, dissemination, evaluation, adoption, implementation--- in the most common context, the public school system. An example may prove useful in explanations intended for those not familiar with the field at all. The example might center around an innovative product developed by a regional R&D laboratory under a federal contract, distributed through a regular educational publisher, purchased by a local school board and used in its secondary schools. There is, in this simple illustration, little difficulty in classifying the two "ends" of the process: the role of the regional laboratory, primarily research and prototype development, is clearly to be classified as "creation and production"; similarly, the utilization by the school fits in box 3, "utilization" (cf. Figure 25 for numbering of boxes). Depending upon how one decides to cut up the pie, the decision of the school board to adopt the product can be part of the "distribution and exchange" process, box 2, or part of "utilization"; on the other hand, in-service training of teachers to use the innovation would appear best to fit under the category "utilization". The publishing firm would have a primary place in the box for distribution and exchange. Evaluation, as a process, can fit in just about anywhere, depending on who does it and for what purpose.

At the level of the "self-evident," the diagram includes, in brackets, the terms that would ordinarily be used to describe the R&D process viewed as an aspect of economic life. It may be useful to soft-pedal economic analogies for publics quite unaccustomed to associating educational R&D (or education) with any framework of reference borrowed from economics. On the other hand, there are numerous uses to which the economic framework can be put, uses which will be discussed further below.

The use of simple illustrations should be engaged in with considerable caution, as their clarity for the layman is frequently bought at the price of confusion for persons initiated in one or another of the discipline frameworks which are used to study the R&D system. The example above can easily raise numerous difficulties, particularly near the center of the process, the transition from creation to utilization, through the "distribution and exchange" portion of the model. Persons familiar with real life situations would be troubled by numerous questions: How did the school board officials hear of the product and how did the publisher seek to reach them? What was the process of decision-making, under whose leadership, in what phases? Was this an isolated product sale, or did institutionalized procedures exist in the school board by which curriculum innovations can be brought about on a regular basis? The answers to these questions raise problems of boundary definition, which would be compounded if the regional laboratory in the example were one of those which took responsibility for directly disseminating and "installing" its products in schools, thereby intervening in the utilisation process.

The difficulties can all be traced to the fact that the example assumed specialization of functions between different organizations. This can be resolved by introducing the concept of infrastructure: the institutions in the example form part of the infrastructure, which is not differentiated by function (though, for many purposes, institutions will be classified in terms of their primary functions); the activities carried out by the infrastructure of institutions can easily be classified on the creation - utilization continuum using whatever definitions appear most appropriate.

Out of the framework elements described here, two require further examination, the concept of infrastructure and the content of the creation-utilization continuum, particularly with respect to the implications of viewing it from an economic perspective.

C. A MODEL OF THE R&D INFRASTRUCTURE

The reporting framework sketched above will accommodate various different models of what is constituted by an R&D infrastructure. This section is intended to explain in greater detail the author's conception of how the R&D infrastructure might be conceived within such a framework. For practical reasons, the model is explained in terms of an appreciation of what are likely to be the monitoring needs of the NIE in the near future.

1. General concept of infrastructure

The model of the infrastructure proposed here is based upon the premise that it is possible to distinguish between the R&d infrastructure, the operation of the infrastructure and the regulator system which conditions both the creation and the maintenance of the infrastructure and its operation. The term "infrastructure" is a generic word referring to "a substructure or underlying foundation" (Webster"s New World Dictionary of the American Language) which is frequently employed in the sense of physical installations such as roads, schools, power plants, transportation and communications facilities and so forth. For the purposes of discussion of educational research and development, it is quite clear that physical installations alone do not determine what one might call the "installed capacity" for R&D. In order to be useful the term must be defined more broadly to include institutional frameworks --- with the implication that these include a certain capacity for work organization--- and skilled personnel, as well as physical facilities. The purpose of this note is to explicate how this broader concept of an infrastructure can be conceived within the framework of a system of regulators which control its operation.

2. Components of the model

Figure 26 illustrates the interrelationships of the major elements in the model of the R&D infrastructure. The dotted lines enclose the elements of the infrastructure proper, separating them from the major elements of the regulator system affecting their operation.

Insert Figure 26 about here

a. The Primary Infrastructure

The "primary infrastructure", designated as 'C' on the diagram, is the basic grouping of elements involved in carrying out R&D functions in a direct fashion. Skilled personnel and equipment facilities are pictured as being included within the institutional framework.

To monitor the primary infrastructure at a given time, one counts the number of institutions, persons and facilities and categorizes them. This is the equivalent of a census and cross-tabulation of the results. The usual cross-tabulation would be by element description and function. The description would ordinarily be, for institutions, their legal status (publicly supported universities, privately owned businesses, etc.); for persons, their qualification level and type (Ph.D. cognitive psychology, etc.); for facilities, their most obvious usage characteristics (buildings, laboratory

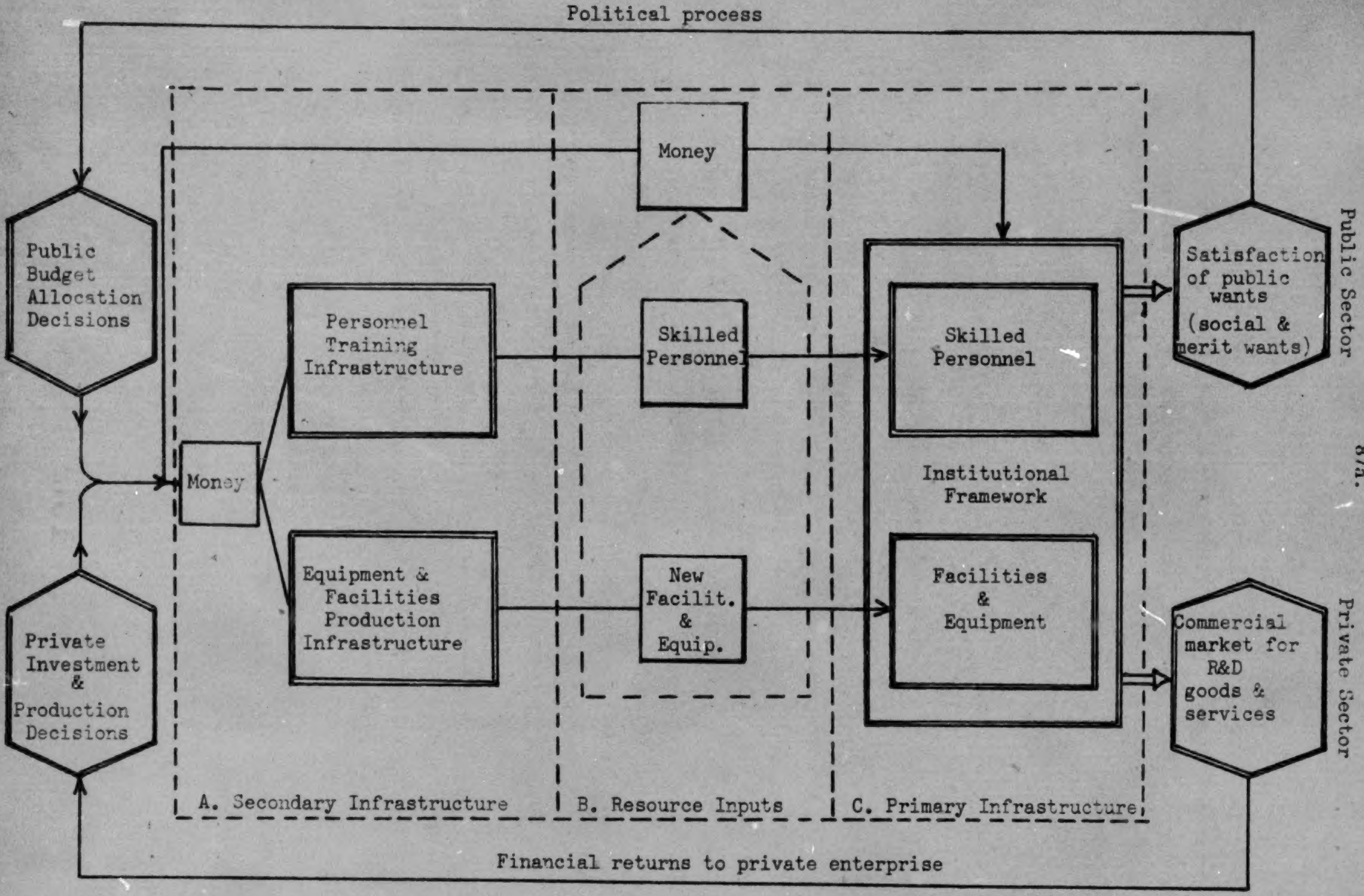
Political process
Public Budget Allocation Decisions
Private Investment & Production Decisions
Money
Personnel Training Infrastructure
Equipment & Facilities Production Infrastructure
Money
Skilled Personnel
New Facilit. & Equip.
Skilled Personnel
Institutional Framework
Facilities & Equipment
Satisfaction of public wants (social & merit wants)
Commercial market for R&D goods & services
Public Sector
Private Sector
A. Secondary Infrastructure
B. Resource Inputs
C. Primary Infrastructure
Financial returns to private enterprise

Figure 26. Model of the R&D infrastructure

equipment, TV studios, etc.). The function classification is ordinarily based upon some taxonomy built around the type of work done, such as "research", "development", "dissemination", (with probably finer categories where relevant), objective sought (curriculum reform, equalizing educational opportunity) or educational public served (secondary school, elementary school science, preschool etc.).

b. Resource inputs

A census of the primary infrastructure will provide a description of its elements at a given point in time. If one seeks to understand its evolution, it can be done analytically on the basis of the factors which constitute "inputs" and whose relative scarcity determine its growth. The prime scarcity factor is, of course, money. In an economic sense, money permits the "purchase" or "rental" of equipment and human services as factors of production. This is shown in section B of the diagram. The dotted lines from money to "skilled personnel" and "new facilities and equipment" indicate that there is a substitution involved between the financial and physical flows. (Raw materials also are inputs to the productive process but are not considered here, as they are considered expendable stocks rather than semi-durable components of the productive process).

Monitoring involves determining how many "units" of a flow occur during a time period: dollars granted per year, students graduating per year, pieces of equipment installed,etc. In practice, the only flow usually monitored, as such, is financial. Personnel and equipment are monitored on a census basis as part of the primary infrastructure and on an output basis upon exit from the secondary infrastructure. The reason for this is that the secondary infrastructure feeds into other sectors besides the one involved here; not all students receiving specialized training in educational research go to work in educational research and all the recruits into educational research do not come from the secondary training infrastructure directly.

In addition to the inflow of resources to the primary infrastructure, there are obviously outflows associated with each factor: money circulates, people move to new jobs and retire, equipment is worn out or retired from use because of obsolesence. Ordinarily these outflows are not monitored * and are not usually of policy interest unless they attain "unusual" proportions: brain drain to other sectors of activity, equipment used extensively for non-productive purposes, etc.

This simple model of resource flows can be expanded and rendered much more detailed. Some examples of the way in which this can be done are given in Section 2 of this paper. In particular, the example of a skilled manpower supply system can be made exactly congruent with this model; the same applies to the schema of financial flows for individual institutions or research units.

c. Secondary infrastructure

The input flows of personnel and equipment are themselves the products of a secondary infrastructure, shown in A of the diagram. The composition of this secondary infrastructure is exactly analogous to that of the primary infrastructure, as is also the process of resource inputs to the secondary infrastructure. The input-output characteristics of such infrastructure relations constitute a recursive loop which can include, theoretically, all productive elements in society.

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* Financial inflows are ordinarily equal to outflows over time, subject to minor adjustments for operating capital reserves. The only major problem posed is how one accounts for large capital expenditures on equipment which is used for research and then, after a time, converted to "normal" use. This might be the case if a special school were built for experimental purposes, then converted to regular teaching. The "Frascati manual" (OECD 1970, para.116) proposes that such disinvestment be recorded separately in estimating R&D expenditures.

The level of detail shown in the diagram is lesser for the secondary system, reflecting its diminishing importance for monitoring and policy-making which are aimed for the most part at the primary infrastructure.

The monitoring of the status of such an infrastructure can be carried out in the same way as for the primary infrastructure. In practice, policy on educational R&D is not frequently concerned with the equipment "flow" or the associated productive infrastructure, except where the equipment is of a particularly specialized nature (media installations such as broadcast and production facilities for educational television) or is itself the object of an R&D effort, such as would be the case for the manufacturing capacity associated with producing equipment for use in computer-assisted instruction. For this reason, monitoring would be confined mainly to personnel training infrastructure.

d. The Regulator System

The regulator system shown in the diagram is intended to show the mechanism which governs the flow of financial resources as inputs to the primary and secondary infrastructure. It does not include a great variety of other regulators which affect the operation and interrelationship of the elements of the infrastructure. These might include, for example, the determinants of personal decision-making for individuals who might be potential recruits into the skilled manpower training system or the numerous factors determining the allocation of production facilities within the equipment facilities production infrastructure.

The prime control mechanism is viewed as being the production outputs of the R&D primary infrastructure (though, in practice, the intermediate outputs of the secondary infrastructure are also considered in analogous fashion). Depending upon whether these outputs are from publicly-supported agencies or from private enterprises, separate feedback mechanisms are involved. The private sector is governed directly by the market mechanism; the rate of financial return is the prime element governing subsequent investment decisions. In addition the private sector is subject to second-level regulatory and incentive practices of public agencies; these regulators are not explicitly shown here. In the public sector, the outputs are considered by a process of political decision-making in the light of what may be called "public wants". The operation of the regulator in the private sector is subject to analysis using the standard tools of the private economist; the framework for the public sector is similarly general and can be made congruent with the usual theories of public finance (cf. Musgrave 1959).

3. Applying the model: How many infrastructures?

Defining the boundaries of the R&D infrastructures involves establishing certain basic definitions about R&D. These definitions can be visualized as two dimensions: breadth and function (cf. Figure 2).

a. How broad R&D

The supply-demand/production-utilization model for reporting suggests strongly the need to monitor the R&D infrastructure along a whole continuum ranging from basic, discipline-oriented research to the final consumer base. However, the consumer base is obviously much larger than the production function in terms of the numbers of institutions and persons involved, quantities of money expended, complexities of relationships etc. For this reason it is necessary to use a different scale of "intensity" for monitoring, gathering progressively less detailed data as the size of the system studied increases; this is roughly similar to using logarithmic-scale graph paper for illustrating growth curves where increase follows a pattern of geometric increase. Accepting the principle of broad monitoring does not mean that equal levels of detail are involved.

b. R&D for whom and for what?

Educational R&D can serve multiple consumer bases. The prime concern of the NIE is with the K-12 system and related components of the formal educational sector. It is possible also to monitor the task-oriented sector and the informal sector. As with the continuum of creation-utilization, this dimension also involves a change in brute size and complexity: the task-oriented sector is larger than the formal sector, and the informal sector far exceeds both in dimensions. For reasons of both size and likelihood of related policy initiatives, a similarly decreasing scale of monitoring is recommended.

c. Monitoring the R&D infrastructure

In principle, one can monitor any element or flow included in the model of the R&D infrastructure. The attached table (Table 1) outlines the author's personal suggestions for the major types of monitoring required within the monitoring system.

D. AN ECONOMIC PERSPECTIVE ON EDUCATIONAL R&D

1. The "social change" perspective

The "distribution and exchange" box in the reporting framework requires to be examined in more detail. Its graphic representation includes as a simple mnemonic device, a dotted line, symbolizing that it is of indeterminate breadth. Depending upon the circumstances, (and the definitions used for describing the circumstances), the functions included within it may be exercised either as part of the creation/production function (active dissemination by an R&D producer), by the user as part of a general set of organizational problem-solving or innovating behaviors, or by a third party (publishing house, information service, ERIC etc.) In most real-life situations one finds a combination of all three sharing the function in a multiplicity of patterns.

There is no method which can be said *a priori* to be the "right" method of viewing this function. The most extensive review and classification of the literature (Havelock 1971) distinguishes three major perspectives or strategies related to the innovation process: "research and development" or theory-into-practice, social interaction and problem solving. It is easy to perceive that these categories divide along the lines of whether the distribution/exchange function is being viewed from the perspective of the creation/production "end" or the utilization "end". The "research and development" or theory-into-practice literature derives largely from writings intended to show how to make the creation/production function more effective, particularly by extending its scope in the direction of utilization ; this literature has led to the current trend of replacing the users "research and development" by a whole string of functions: research, development, dissemination, demonstration, adoption, implementation, etc. By contrast, both the "problem-solving" and the "social interaction" approaches result from visualizing the process from the utilization "end". (Havelock's proposed synthesis, a "linkage" model, is traceable to the superimposition of a communications network approach upon the interactions viewed from the "user" perspective).

Whereas it is possible in retrospect to see in the literature a clear division between the production-oriented "research and development" model and the "problem solving" and "social interaction" models, time is tending to blur the distinctions: users must be concerned with a reliable flow of information and products; producers cannot ignore the desires of the users. Either is futile without the other. At either end of the spectrum, whether near "basic" research or day-to-day educational administration and operations, there is clear differentiation of concerns; but from whatever end the production/exchange function is viewed, there is a convergence.

This converging literature (cf. the references cited by the authors mentioned earlier, Havelock 1970, 1971, Dalin in press, Fullan 1973, Huberman 1973) is unified by its concern with the process of change, defined either explicitly or implicitly as intended to result eventually in a change in the behavior of the participants in the teaching process. The unifying traits which characterize these studies might be summarized as follows:

a) They are almost entirely concerned with the human factors affecting change in the educational system and how to organize or modify these factors to operate more effectively. Much of the literature, particularly during the 1950's and early 1960's, dealt with leadership roles and the process of decision-making, sometimes in the form of proposals to adopt certain procedures (PPBS, "systems" approach, etc.). The perception that formal decision-making structures and the actions of authority figures were often unrelated to actual teaching practice in the public school system, has led to progressively more probing analyses of how information and resources (new products etc.) are transmitted to the user and what conditions make possible their application. As Fullan (1973) has pointed out, even with probing has failed to recognize that the "user" in the teaching-learning situation is not only the teacher but also the student and, in an ultimate sense, the society in which both live.

b. One finds in the literature the same sets of assumptions identified by March and Simon (1958 p.6) as underlying the literature on organization theory. They grouped these underlying assumptions into three broad classes, each concerned with what properties of human beings have to be taken into account to explain their behavior in organizations:

> ...that organization members, and particularly employees, are primarily passive instruments, capable of performing work and accepting directions, but not initiating action or exerting influence in any significant way.
>
> ...that members bring to their organizations attitudes, values, and goals; that they have to be motivated or induced to participate in the system of organization behavior; that there is incomplete parallelism between their personal goals and organization goals; and that actual or potential goal conflicts make power phenomena, attitudes, and morale centrally important in the explanation of organizational behavior.
>
> ...that organization members are decision makers and problem solvers, and that perception and thought processes are central to the explanation of behavior in organizations.

These assumptions are recalled here because the assumptions built into the framework of analysis used, will determine the type of conclusions one draws about the interface between the R&D creation/production function and the utilization function.

2. Prior proposals for "market models" of R&D in education

It is interesting to note that the volume of material on educational R&D written from the "social change" perspective is not matched by any similar flow of publications reflecting concern for the economics of R&D. One may hypothesize that this situation results from the comparatively low level of investment in educational R&D. As a proportion of Federal R&D expenditure, measured using the definitions of the National Science Foundation, education rose from 0.1 per cent in 1963 to 0.8 per cent in 1972 (NSF 1973, p. 26). A parallel hypothesis (admittedly without real evidence) is that the failure to consider the economic effects of investment in educational R&D may have been one of the causes for the low level of support which it has traditionally received.

If one leaves aside articles reporting current levels of expenditure on educational R&D and commentary on how a given year's federal (or given institutional) budget might be divided up; one is hard put to find a handful of articles that view educational R&D in an integrated fashion as an economic sector. Current funding levels have sufficed to bring educational researchers and similar persons to write on the educational R&D sector but have apparently been insufficient to inspire major economic analyses.

To the author's knowledge, the only possible exceptions to this lack of a general economic perspective are provided by certain proposals found in the literature for treating R&D according to a "market" model. Perhaps the best known proposal in this vein was put forward by Gideonse (1972). The basic statement of the model concept is in the following quote:

> Educational research and development must be conceived in terms of the market, consumers, and clients it is supposed to serve. Only after that principle is firmly established should attention be directed to the processes, techniques, and functions which might accomplish that service. Prerequisite to the application of science to education is the examination and redefinition of what the education market is, what it means to consider clients or practitioners as a "market", and how to translate market requirements (conceived either in present terms or desired future terms) into product or outcome statements that will provide useful guidance to the development of research and development policies and practices. (underlining in original).

As pointed out by Clark (1972) in an accompanying critique, the model is not a model at all, but instead a single concept. It might be rephrased, in my view, as an appeal to use the needs of the potential users of R&D products as the basis for designing and developing the products. Gideonse recommends that attention be given to the distinction between producing goods (or services) and satisfying customers:

> The key point... is that those industries that have maintained a posture of satisfying customers have thrived; those that have concentrated on producing goods have either stabilized or gotten into serious difficulties.

In essence, Gideonse has recommended a "marketing" strategy for managing research and development, rather than a "market" model.

Another line of thought on the subject has been to consider the weakness of the current R&D system in the light of economic behavior in the private sector of the economy. In the same collection of papers with the Gideonse article, Glass and Worthen (1972) go even farther, proposing to move"schooling out of the grants economy and under the influence of the market mechanism"; once that has happened, they say, educational development and diffusion would "flourish". The major part of diffusion would also be moved into the private sector, according to their proposal.

The brunt of their argument is concerned with changing education to fit a simplified, partially managed laissez-faire market model; in turn, they feel this will cause educators to change their behavior patterns. It is the converse of the Gideonse model, which respects the wishes of the consumer; here the intent is to use the market as a force to make the educator change to fit their view of a good R&D consumer. In sum, it is a proposal to change education, not a model of a market mechanism for R&D, at least not any mechanism that might conceivably exist in the near future.

Beginning with similar premises, Pincus (1973) arrives at a far more realistic set of proposals, most of which have direct bearing upon educational R&D. His paper compares the public schools, which he describes unflatteringly as "self-perpetuating bureaucracies", with the "competitive firm", attempting to pinpoint the differences in behavior patterns which result from the different incentive structures of such organizations, particularly behavior patterns likely to affect the adoption of innovations in administration or teaching practice. Pincus's approach is that of "restructuring incentives" and, although he does propose experiments with systems such as voucher alternatives to the usual obligatory attendance schemes for public schools, the intent is to accept schools as they are (or as Pincus perceives them to be), without simply proposing the abolition of their current structure. In other words, from total catastrophic change of the type proposed by Glass and Worthen, there is a shift to marginal manipulation of incentives, a standard marketing technique. At the formal level, Pincus is proposing to consider the schools in their role as a sort of marketing organization; supplying or 'producing' education; the market being considered is the market for education, not R&D. Underlying the whole paper and its numerous insightful suggestions is, however, a fundamentally different concept, that the school system is also a 'consumer' of innovations and new ideas. Since the concept of a market for R&D is not enlarged upon at any point, we are probably dealing less with a model than with an analogy. Or, to be more precise, we have a potentially very useful model of the incentive structure of the public school system, viewed as a "consumer".

3. A proposal for a supply and demand or "market" model of R&D

Although this brief review of "market" models of educational R&D has shown the incompleteness of the models proposed, the author is convinced that considerable benefit would derive from pushing this analogy further, using it as a basis of research and explanation for certain aspects of the operation of the educational R&D system. The utility of such a framework for explanatory purposes appears so obvious that it has been included on the proposed reporting framework, with the associated terms placed in brackets. The concept of a supply-demand situation is so widely understood in our society as an organizing concept for the delivery of both goods and services, including public services, that its generalization to the field of educational R&D would provide a conceptual framework almost universal in its accessibility.

As the author is not an economist by profession or academic credentials, he feels it necessary to sketch here only the general outline of what appears to be a useful approach to using the market concept of supply and demand as a model for certain parts of the educational R&D system. All the remarks below are therefore preceded by an implicit, "to the best of the author's understanding."

a) The basic concept

In economic writings the term 'market' is used in a variety of acceptations, ranging from the narrow physical sense of a meeting place for buyers and sellers, to the mathematical theories of how supply and demand interrelate, to the very broad concept of "the entire web of interrelationships between buyers, sellers, and products that is involved in exchange" (Steiner 1970, p. 575). In this sense it is impossible to separate the concept of market from a host of other considerations. The market is an exchange mechanism governed, in principle by "supply" and "demand"; associated with each of these is a "production" and a "consumption" function. Much of economic thought in the past two centuries has gone into explaining how the setting of prices within a market serves to bring supply and demand into equilibrium over a period of time by regulating the allocation of resources within a society (Arrow and Hahn 1971). The simplest textbook model shows how oversupply leads to lower prices and lower income for producers, creating a disincentive to production, and vice-versa; on the demand side of the market, changes in prices have an analogous effect by encouraging or discouraging consumption, the whole resulting in a dynamic series of adjustments tending to bring production and consumption into equilibrium. In essence, this is the basic mechanism which, it is proposed, should be considered the center of a supply and demand ("market") model. Two reasons appear to explain why so little use has been made of this phenomenon in analysis of educational R&D.

The first reason is either that most writers on the topic are preoccupied with the content of the educational reform or improvement that R&D may achieve, or they do not associate market phenomena with educational institutions. The transactions involved are, however, quite straightforward. In a simple case, the user pays directly for what he receives, as when a school board purchases text books. This transaction ultimately pays for the development which went into the creation of the textbook. Other transactions occur between two subsidized, state-supported institutions with no monetary flow involved between the two. This is not a change in the basic nature of the transaction, simply a different type of flow. In one instance, financial inputs from a tax base are used by a school board to buy the product directly; in the other financial resources pass via a subsidizing agency to the R&D producer, who furnishes the service "free of charge".

The other reason is associated with a basic confusion between the term "market" and doctrinal stands on how the nation's economy should be run. Various political and economic doctrines have been erected on the foundation of supply and demand, their crux being in determining the effect of allowing the market mechanism to operate "freely"; the discussions range from the Marxist tenet of the impoverishment of the proletariat, through the question of whether the market mechanism results in the optimal allocation of resources, to the issue of whether international free trade is beneficial. It is important to realize, therefore, that in talking of a "market", one has not automatically endorsed any belief structure associated with it, such as the advantages of free enterprise and/or *laissez-faire*. In the context of the United States economy as it is presently organized, even brave talk of moving education "out of the grants economy" could hardly be interpreted as *laissez-faire*, since the U.S. economy is regulated and controlled in a great diversity of ways by federal and state governments. The underlying justification of such intervention is, in fact, the imperfection of the market mechanism as a regulator for economic life. It bears repeating: *Speaking of a supply-demand model for educational R&D does not mean subscribing to an unregulated, price-controlled market mechanism.* Having said this, the author nevertheless feels it necessary to point out that, particularly in publications intended for a non-expert public, the terms "supply and demand model" is probably preferable to "market model"; the former is less likely to encourage confusion on this point.

Using the supply and demand concept to describe educational R&D raises numerous theoretical problems. Rather than view these problems as obstacles, one should probably treat them as challenges. In all likelihood, studying them will shed considerable light on other aspects of R&D viewed as a social change mechanism. The following appear particularly noteworthy: defining general market structures; studying specific products and services; distinguishing between educational products and educational R&D; relating the concept of "need" to the concept of "demand", and extending the analysis of economic benefits to other sectors than public education.

b) Defining market structure

The usual theoretical distinctions are based upon a categorization of the role of the suppliers in a market, so that one distinguishes between "perfect competition", "monopoly", "oligopoly", "monopolistic competition" and a host of other variants (such as the "grants economy", referred to by Glass and Worthen). With regard to educational R & D it is clear that a variety of classifications would result, depending upon (1) the nature of the product being considered and (2) the sector being served. The market for the training needs of private business firms differs markedly from that of curriculum packages aimed at the public school system. The former approximates closely to the situation of free competition (via a host of small consulting firms and individual consultants), whereas the latter is sui generis: private firms compete with subsidized producers (R & D laboratories, etc.) but sometimes derive an indirect subsidy from them by obtaining distribution rights to products developed at public expense; the products are marketed to an oligopolistic consumer base (dominated for textbooks and many curricular materials by the California and Texas markets) that is cajoled into using them by a helter-skelter array of incentives and information systems of dubious efficiency. (---A "mixed subsigopoly", shall we say?)

Simple labelling aside, the over-all structure of supply and demand for R & D products (goods and services) is hardly charted either by educational sector or by product. Our lack of knowledge on the matter is abysmal. Do we have any basis for predicting, for example, the impact upon "demand" (defined as acceptance by consumers) of increasing total federal subsidies to R & D producers twofold? tenfold? Is there any basis for supposing that the increase in subsidies would be matched by a proportionate increase in "supply"? Do we have excess productive capacity, only waiting for an increased monetary demand? The answers to these questions, involving the simplest (to perceive) concepts of elasticity of supply and demand, are quite beyond us today. In fact, they are practically unavailable even for a handful of products.

c) Studying specific products and services

Up to this point, we have been discussing markets in terms of aggregate supply and demand for R&D products. This simplification to a unified market is dependent upon our ability to sum supply and demand for large numbers of products; however, as we have said, there is little raw information on which to base generalizations. The remarks made earlier concerning the structure of the market for textbooks and the dominance of two states in that market, for example, corresponds more to hearsay evidence than any assessment of real data. Numerous product marketing histories are required to begin delineating how educational R&D markets vary. For instance, it appears obvious (but may not prove true) that the distribution of consumer "clout" is probably far different in the field of marketing language laboratories than in the example given above of textbooks. On the other hand, it is also clear that the market for teaching aids as a whole is subject to quite specific universal constraints, resulting from the fact that budget patterns tend to change slowly and most public education budgets are used for salaries.

Detailed knowledge of the financial structure of the market for individual products may be vital to definition of product development strategies and to public policy. For example, if one discovered that some area of development were being largely ignored by the private sector and by publicly subsidized R&D institutions, such knowledge would make it possible to make a more rational allocation of public support funds in the area. At one extreme it might turn out that the whole research-development-distribution-installation mechanism was extraordinarily expensive compared to the potential buying power of the intended market, thus ruling out the possibility of basing R&D strategies on the private sector and making it necessary to create a subsidized operation from beginning to end. At the other extreme, one might find that several private companies had given a try in the field before and been "burned" just slightly, barely recovering their investment; if one could track down the specific causes of their problems --- insufficient product research to render it effective, high training costs borne by the marketing firm to initiate potential customers to the new product and its usage, tendency of customers to buy the product without being able to afford maintenance for it, etc.---, it might be possible to achieve the desired effect by a low-cost program aimed at solving the specific problem, not replacing the whole existing development and distribution mechanism.

d) Defining the R&D content of economic transactions

This example raises an important issue which has not been addressed so far: The "products" discussed here have generally consisted of two elements. The first is the visible good or service provided to the educational user. The second is the invisible R&D proportion of that product. What proportion of a textbook in science, for example is "R&D" and what proportion "routine publishing and distribution"? Surely it cannot be that R&D is the portion of the work that is subsidized by the National Science Foundation or the federal government, as opposed to the portion that is carried out by private enterprise without help. This throws us back to the problem of criteria for defining R&D, discussed in the previous section. In most cases the distinction can be shown symbolically by referring to the concept of "prototype" development and linking it to the creation/production function in the model. However, there are numerous cases where the R&D product requires what one may call a 'clinical' approach to users with follow-up assistance. It is essential that any economic analysis of educational R&D take this into account. The fact that a product is acquired at a given point in time may amount to only a portion of the total transaction to be considered. The other portion of the transaction is made up of the services furnished at a later period in time.

Thus, we are faced with two intermingled problems: (1) The total product transaction does not necessarily occur with the initial transfer of goods or services; there may be follow-on components delayed in their arrival; some of these may even be provided by other sources than the original furnisher of the R&D product. Curricular materials might be marketed, in the sense of physical products, by a publisher, but the original developers could easily be involved in providing support to the users in the form of training workshops under a special third-party grant; this was the case of Harvard Project Physics, to name but one example. (2) There is the definitional problem related to this transfer for the purpose of defining a market. A market for educational products is not synonymous with a market for educational R&D. Whatever criteria one may choose to adopt in determining what constitutes R&D, it is necessary to make the distinction between routine production and R&D.

e) The relationship of "demand" to "need"

The acquisition of educational products in school systems is determined by a decision-making procedure which usually involves the intervention of school boards and taxpayers in fixing budgets and administrators in spending the budgets. The same applies to any redistribution of resources which may be involved in carrying out an innovation. These mechanisms and decision-making structures account for the structure of effective demand for educational goods and services. On the other hand, there is no guarantee whatsoever that decisions made by these structures --- for example, to introduce a new teaching method in connection with a new educational product --- will result in any change in teacher behavior. Thus, in theory, provided the decision-making structure continues to show its interest in acquiring the outputs of educational R&D, it does not matter whether this effective demand corresponds to any actual application.

The opinion of those who implement educational changes constitutes what one might call a "second-level" demand structure. This demand structure is not necessarily expressed by a poll of opinions, as willingness to agree to use a new method or device does not in any way guarantee that, no matter how sincere the educational practitioner, he will be able to change his own behavior effectively to match the expectations of the innovation so introduced. This behavioral substrata of demand is a level beyond the usual expression of willingness or unwillingness to acquire; it is the cause of numerous failures to follow through with innovations.

In short, anomalies in the structure of demand result in well-documented difficulties. Demand is not necessarily matched with practitioner willingness-ner, given willingness, with practitioner ability to put an innovation into practice. This second-level demand structure may well be organized and studied in order to bring higher-level decision-making into accord with it. However, in order to be complete, one should also try to go beyond the structure of demand to consider the structure of "need". Needs may be expressed at the individual level of the educational client, the child in the regular public school system, or they may be manifested at the level of the community. Various dimensions of these need structures are the meat of many educational research studies; seldom have they been associated with an economic analysis of the framework of demand.

There is a great public policy need to begin the theoretical and practical task of sorting out the structure of need and demand. It is in sorting out this structure that the role of the federal government is most clearly called into question. For, by definition, the investment of public funds in any aspect of educational R&D is an intervention to create an economic demand.

f) Analyzing the economic benefits of educational R&D in the task-oriented education sector

To the author's knowledge, there is little reliable data in existence which clearly relates the benefits of improving task-oriented education to increased wor productivity. Such an analysis will probably reveal large sectors where minimal public investment will result both in direct benefits to the business employing trained persons and, through diminishing social welfare and other costs, to the economy as a whole. It is only in the presence of such data that a rational allocation of funds can be made between R&D activities serving different sectors.

Cumulatively, the areas of potential study using this framework are so important that, in the author's view, they cannot be postponed. Their results may cast a more practical light upon the prospects of speaking of a "supply-demand model" of educational R&D.

Section 4. Implications, Recommendations, Suggestions

While preparing this paper, the author has had the opportunity for extensive discussions with NIE staff members regarding the general problems of developing the national R&D system and the specific question of creating a specialized monitoring unit at NIE. The pages of this paper contain numerous methodological suggestions. The following is a summary of the author's major recommendations and suggestions that affect policy on monitoring:

1. There is a clear need for the creation of a specialized monitoring unit at the NIE. (It is the author's understanding that a preliminary decision has been made to create one).
2. The monitoring unit should have a broad mandate. It should not be limited to doing policy-related monitoring. The monitoring function should be set up in such a way as to serve three major functions:
    a. External communication and public accountability
    b. Internal policy making
    c. Research on the system

    The implications of these functions are spelled out in the next points.
3. External communication and public accountability

    The external reports of this unit should not be conceived as a means of justifying NIE policy, either past or present. The NIE is more than an operating governmental agency; it is an independent guardian of the free processes of inquiry and criticism by which educational reform should be carried out in a democracy. A monitoring unit within it must be given the autonomy to publish the facts as they appear to be, on a regular basis and without distortion or suppression.
4. Internal policy making

    As time goes by, the monitoring unit will acquire a fund of knowledge about the operation and structure of the national R&D system which will be invaluable for the assessment of policy proposals. This information should be brought to bear on all major policy issues at the NIE, not only the policy issues related to the programs of the Office of Research and Development Resources.

In particular the information available should be brought to bear by policy planners on the crucial problem of assessing the cumulative impact on the R&D system of separate, discrete policy initiatives that are apparently unrelated to each other.

5. Research on the system

   The monitoring unit should regularly pursue research on aspects of the R&D system which are not directly related to policy problems or the need for accountability. Obvious budgetary constraints will require that the portion of independent funds reserved for this purpose be small. Much can be accomplished, however, by indirect methods: (a) helping other units of NIE to make use of their own research initiatives to provide by-product data; (b) analyzing secondary sources external to NIE; and (c) paying for "piggy-back" data gathering where research carried on by others can be usefully expanded to include matters of interest to the monitoring function (e.g. by approaching NSF for assistance).

The functions outlined above have major implications for operations, including the following:

6. Scope of study

   The definition of the monitoring task should be broad:

   a. educational sectors: The author is aware that current NIE concerns are almost wholly in the K-12 sector with its extensions (primary certification sector). However, monitoring should also include the task-oriented sector (related to professional and vocational activities) and the informal sector, though with limited expenditure of time and effort. Both are likely to emerge in the near future as areas of major public concern.

   b. definition of R&D: Monitoring should not be limited to a traditional, academic-oriented concept of R&D. It should include functions in the areas both of "distribution and exchange" and of "utilization." However, data gathering should include a definitional framework such that the traditional R&D areas can be compared directly with figures provided by the NSF.

c. definition of "system": Although it is usual to think of monitoring the R&D system in terms of counting elements (institutions and people) in the infrastructure and totalling dollars spent, the monitoring function should not be limited to this sole task. Monitoring should also include the other areas outlined in this paper, particularly regulators and R&D throughput (activities) indicators. Due to the absence of reliable indicators for throughput and regulator systems, the study of the latter should probably proceed primarily on the basis of one-time studies or the analysis of secondary sources, rather than by repeated measures of the same indicator over a period of years.

7. Reporting framework

Poor communications are a major stumbling block in the development of educational R&D. The NIE should adopt a broad general framework of reporting and retain it in all publications on the R&D system for a period of years. The specific framework proposed in this paper might serve the purpose, or some other could be used. However, it is important that, whatever framework is used for reporting, its clarity and comprehensiveness as a "bird's eye view" of the whole enterprise should not be any less than the proposed framework. The practical utility of a consistent communications framework is enormous, provided that the framework meets the following conditions:

a. Its formulation should be neutral, that is, acceptable to all publics of NIE. This means that its formulation should not be tied to the most commonly accepted models of R&D (e.g. dividing the spectrum of activities into research, development, dissemination, adoption, implementation). For large parts of the educational community and the general public, the applicability of these concepts is subject to debate, if not outright rejection; for parts of the scientific community, their validity as a description of how change occurs is subject to qualification or doubt.

b. The formulation should be broad enough to permit discussion wihin its bounds of different models of R&D and social change, e.g. the discussion of the relative merits of a planned, R&D approach to change as opposed to a grassroots, user-initiated problem-solving approach.

c. The reporting model should clearly show, at a glance,[*] all the major interacting components of what is meant by an "R&D system." Only with considerable difficulty can the trained reader of literature on the R&D system determine what portions of the over-all picture are being dealt with by a given writer. Such confusion cannot be tolerated in NIE publications.

8. Economic studies

Economics is not the only discipline base from which the study of R&D can be carried out. However, the nearly total neglect of economic studies of educational R&D should not be allowed to persist. Particular importance should be attached to studying the economic implictions of R&D for the task-oriented sector.

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[*] The proposed reporting model has one characteristic: Graphically, distinctive shapes are given to the elements; some similar system might be used as a "logos" in publications, with the portion under discussion being identified by a solid color. Such a visual referent would greatly facilitate understanding of publications.

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Table 1. Typical Indicators for Monitoring the R&D Infrastructure

	Regulators	Secondary Infrastructure	Primary Infrastructure
1. Institutions	1. Public institutions only	1. Institutions - all training institutions - selected equipment production units	1. Institutions generally
	a. identity of institution, type description	a. same	a. same
	b. general domain of action	b. same	b. same
			c. "market" or consumer base served by institution (market for producers, target or market for distributors, educational public for utilization sector)
2. Money	2. Money outputs (given away), public institutions only	2. Money inputs (received)	2. Money inputs (received)
	a. quantities of money, financial period, to whom	a. same, except from whom	a. same as secondary infrastructure
	b. policy goals related to money, recent changes	b. particularly noteworthy institutional goals and policies, if divergent from grantor	b. same as secondary infrastructure
3. Skilled personnel		3. Personnel training system	3. Personnel employed
		a. types (age, qualifications) of entering persons, numbers	a. types (qualifications) of persons working, function to which employed, numbers
		b. types and range of training offered	

	c. teaching personnel (numbers, qualifications, areas of teaching) d. types of persons leaving (age, level of additional qualification received, area of specialization), numbers	
4. Equipment and facilities	4. Production system a. case descriptions of selected equipment types produced (numbers, use, value)	4. Installed usable equipment and facilities a. same, with reference to types of equipment installed b. users of selected equipment types or public served

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* The extent of monitoring (i.e., level of aggregation of data gathered) will be less intensive as one progresses along the spectrum from creation/production to exchange/distribution to utilization.

APPENDIX A

An Information-Agent Interaction Model of Knowledge Organization and Utilization

The author feels it necessary to relegate to this appendix his own, entirely personal view of how research and development fits into the world of knowledge. This view is so general as to be useless for any practical purpose; in addition the author has neither the depth or breadth of knowledge to undertake such a synthesis or to probe its implications. It is offered only as a footnote. The main body of the paper does not depend upon its consistency or accuracy, except as regards personal vision during writing.

Over a decade ago Fritz Machlup published a book whose title has passed into the language: Production and Distribution of Knowledge in the United States (Machlup 1962). His book sketches a broad panorama of the sectors of American society for which information handling in various modes is the essential basis of activity. The phrase "production of knowledge" may have connotations which do not stand up to rigorous analysis, but it does accurately convey Machlup's concern for the economic aspects of information handling. The title is a good starting point for beginning to develop a different understanding of the content of R&D.

Let us begin by substituting the word "organization" for "production" to give the phase: "organization and utilization of knowledge." The change has utility, for it immediately opens the door to a reconsideration of the stereotyped roles assigned in most models of R&D to the researcher, the developer, the "linker," or the user of R&D products. In addition it leaves aside the kernel problem of how knowledge comes into being, a problem best left to those who worry about matters such as the origin of the universe. Instead of looking at the ultimate origin of knowledge we shall focus upon the consequences, the "output" of the creator of knowledge. For the moment, we can consider this creator to be a researcher. The conclusions derived from analysis of the researcher's activity can subsequently be generalized to other participants in the R&D process.

The scientific researcher has as his objective a new structuring of some portion of the societal knowledge base of his time. Scientific hypotheses are statements of relationships, the "structures" or "organizers," which he provides in terms comprehensible to fellow scientists. To borrow terminology from Popper (1964?), he provides conjectures, the refutations of which lead to new, "better" conjectures, the sum of existing unrefuted conjectures constituting at a given time that body of "knowledge" commonly called "science." In other words, each researcher adds to the sum of organized knowledge. In terms of content, he contributes what we might call "added organization of knowledge" similar to the "added value" contributed by the enterprise in the economy (cf. tax reform proposals to create a "tax on added valued"). His scientific activity constitutes an interaction between himself, the surrounding world and the societal knowledge base; at some instances that interaction may be personal reflection, at another, the design of a series of empirical tests whose results he will confront with his own understanding of the knowledge base, resulting either in a reformulation, or the confirmation, of a portion of it --- an added degree of "organization of knowledge."

At this point, the model of scientific activity has a certain abstract, logical simplicity. The human implications are less simple. No scientist can ever be said to "know" all of the societal knowledge base, not even those portions of it which were contributed by the formal processes of organized scientific research; the knowledge base in society is obviously greater than the knowledge accessible to a given individual, his personal knowledge base. The student of the behavior of researchers is aware of the degree of chance involved --- even in the best structured and planned environment --- in the process of scientific discovery. The term "heuristic" is used to describe our conception of how a person grapples with the infinity of possible sources of data to come up with a restricted set of those data capable of guiding his thought and action. The process of personal cognitive growth for the individual, researcher or not, can be equated with the accretion of heuristics for symbol manipulation and for behavior; it is hardly likely that the path of the scientist in this regard is essentially different from that of the child: Popper's view of conjectures and refutations in the scientific world is the exact analog, in fact the conscious refinement of, Piaget's view of cognitive development in the child (cf. Piaget 1972). The interaction between societal knowledge base, personal knowledge base and personal activity is the process by which each individual adds to the store of knowledge. The neutral term for the principle governing this process is "feedback"; a highly controversial viewpoint on the implications for education of manipulating the process is associated with the writings of B.F. Skinner.

The personal knowledge base of each individual may be seen to consist of, at least, two components: a certain body of ideas deriving from the formal processes of "scientific research" (usually assimilated through indirect means, not by personal research) and a much larger knowledge base gathered informally through personal experience. This internalized knowledge may be extended for a given practical use by accessing outside sources of knowledge (rumors carried by word of mouth, encyclopedias, microfilms of scientific treatises, etc.). Human groups, as entities, have a knowledge base which is distinct from that of the individual but similarly composed of "scientifically" derived and informally derived components; the human group is, in essence, a storage medium for knowledge and group interactions (rituals of behavior, rules of hierarchy, administrative procedures, etc. , constitute an accessible form of knowledge which individuals draw upon to shape their actions). Assuming that there is a difference in immediate origin for these two classes of knowledge, we shall refer to them in the following as "scientific" and "non-scientific" knowledge, the reference being to the origin, not the content.

The test of scientific knowledge is that persons other than the originator of the knowledge be able to act upon it in the same way with the same results. In the physical sciences it is generally understood what is meant by "acting upon" scientific knowledge; when observed by different persons, the interaction of certain phenomena under defined conditions gives results predictable on the basis of the scientific knowledge. The meaning is less clear in the social sciences where the difficulty of reproducing initial conditions (or, for the historian, defining what the initial conditions were) make this standard difficult to apply literally, though it is an acknowledged goal in most disciplines. In summary, "added organization of knowledge" in the sciences is measured by the degree to which there is an increase in the ability of third parties to act upon organized knowledge with reliability. By this measure, the impact of Newtonian physics is clearly understandable in terms of its ability to guide human endeavor in multiple domains for centuries, until research on wave motion and atomic and sub-atomic physics demonstrated its insufficiency as an explanatory mechanism.

The test of non-scientific knowledge is that persons other than the originator of the knowledge be able to act upon it in a consistent way with --- in their understanding --- the same results. This process differs from the scientific validation process in terms of the much broader limits assigned to the human understanding. The scientist's task is to limit the free play of individual understanding by defining conditions so that, in theory, all men will derive the same results under the same conditions concerning the phenomenon being considered. The measure of "added organization of knowledge" is exactly the same for non-scientific knowledge, the degree to which the addition increases the ability of others to act upon the knowledge base with perceived reliability, the assessment of reliability being more dependent upon the judgement of the individual observer. This "measure" has the characteristic of reducing to a common dimension the impact of the ideas of a Muhamet and a Newton.

The relationship of these two types of knowledge to research and development activities may be understood by returning to our prototype scientist or researcher. Except for narrowly defined domains of specialization, scientists guide their behavior on the basis of non-scientific knowledge, knowledge imbeded in every word they say, in very social custom they observe or choose to flout. Behavior guided by rules derived from science is an exception, even for scientists. The modern technology called "R&D" has been concerned with how to use, or organize the use of, this narrow swath of scientific knowledge. The main applications of R&D which have proved successful are in the production of physical items -- the development of, say, telephone networks [The term "system engineering" was first used in Bell Laboratories (Hall 1964)] , weaponry and the physical impedimenta of our consumer society. Success in other domains has been inversely proportional to the degree to which the object of the process was a shift in behavior of human groups. Medical research, for example, has given us techniques which control viruses, but few which change the collective behavior of doctors, patients, or politicians; the richest country in the world makes access to health care dependent upon the hazards of personal birth and wealth. Asking "medical R&D" to change this situation is analogous to asking "educational R&D" to overcome the cognitive disadvantages produced in children by living in a ghetto. It is symptomatic that few consider it the business of medical R&D to reshape the delivery of medical services but there is general agreement that educational R&D can provide something called "compensatory education." The perceived success or failure of these two branches of R&D is dependent upon the degree to which their assigned goals involve a change in human behavior on a large scale. In laboratory situations methods exist to assist the disadvantaged child, methods which, to be truly successful, would require that the "treated" child be nurtured thereafter in a non-disadvantaged environment. This cannot be practiced on a broad scale without massive changes in the structure of both his society and his schools, changes which presently are both beyond the scope of educational R&D and of education.

Let us accept as given that the goals now assigned to educational R&D are goals involving social change on a broad scale. What does this mean with regard to the two types of knowledge referred to above? There has been an assumption present,both in the literature on R&D and in its practice at all levels, that the problem of social change can be equated with the problem of how to make sure that scientific knowledge is utilized in educational practice. This assumption deserves to be questioned in a fundamental way (cf. Thayer 1973). To begin with, if the educational system is conceived of as a social system, then it is evident that the thing called educational "practice," the aggregate behavior pattern of all persons involved in the system, is founded primarily upon non-scientific knowledge sources. Even great success in "translating scientific knowledge into practice" will not alter more than a small proportion of this aggregate. Major changes, such as radical decisions to redefine societal goals for education or to restructure the educational system, are likely to be made in response to knowledge which is hardly scientific in origin and through processes which are certain to be unsystematic. This implies that one is faced with a choice: Defining educational R&D to mean the translation of scientific knowledge into practice is to place severe limits on the changes which can be effected; on the other hand, if one says that major changes must occur and they must be derived from the scientific knowledge base, then one is assuming the suppression of non-scientific knowledge forms as a root of social behavior, something which is manifestly not possible in parctice. The alternative is to give up the equation between R&D and scientific knowledge, perhaps assigning as a goal the use of as much scientific knowledge as possible in the process but recognizing the limits upon its use.

If one gives up the fixation upon scientific knowledge,it is possible to perceive the whole R&D process in a different light. Looking along the spectrum of activities assumed to separate research findings from utilization in practice in certain models of R&D (research, development, dissemination, adoption and implementation, or something of the like), one discovers a repetitive pattern of interactions between agents and the societal knowledge base. The scientist's specialized role in life is to make contributions to the "added organization" of scientific knowledge, a process which combines heuristic probes with rigorous methodology for testing validity of hypotheses; the developer combines some scientific knowledge with (if he is to be successful) much inspiration and common sense to produce a developed product; the "linkage agent" draws upon, for example, objective evaluation data on an educational product and combines it with his personal knowledge of people and situations to assist the practitioner to use the product or decide not to use it on some reasoned grounds; the practitioner decides to adopt the product and applies it in his individual circumstances in the light of objective, verifiable information and much intuition --- the same intuition which gets him promotions, avoids personal embrassment in social situations and decides when disciplinary action is called for on the playground. Upon analysis, each person along this line combines large measures of intuition with verifiable objective knowledge to meet certain goals. The goals differ and the required training for each role differs, but the essential process bears a remarkable resemblance, so close that it becomes difficult to distinguish one phase from the previous.

No difference between a teacher and a scientist? Certainly they differ in terms of the content of the transaction and as regards the refinement of the methodology, but definitely the over-all structure of the process is the same. The "successful" classroom teacher's behavior is rewarded by innumerable happenings in his environment (reinforced, Skinner would have us say), resulting in a cumulative pattern of behavior which is a form of empirically-based but non-scientific knowledge. The teacher's innovations and improvisations --- they may be no more than how to organize an ill-designed cloakroom characteristic of a particular school building --- are a communicable form of knowledge. The complex behavior pattern by which the teacher develops a knowledge of his trade bears a strong resemblance to the complex behavior of the trained researcher...probing, improvising, testing. The process may be carried out without the researcher's level of self-awareness, but it occurs all the same. Insofar as the outcomes are usable by others with reliability of results, some added organization of knowledge has occurred.

An objection may be raised that scientifically demonstrated knowledge is universal in its application and, therefore, is endowed with different properties from non-scientific knowledge. From this it would follow that we are dealing with a different entity and, thus, with a different process. This is to ignore two fundamental issues: (1) The first has been referred to earlier. Since the overthrow of Newtonian physics as the ultimate explanatory system of the physical universe, it is hardly possible to speak in any rigorous way of scientific "laws"; such laws must forever be ringed with a tinge of doubt and should be considered hypotheses for which no counter-proof has been found. The knowledge we have called "non-scientific" is distinguished only by the ease with which counter-examples or refutation are usually found. (2) Human behavior is not mecessarily changeable by rational processes. Cigarette smoking continues to progress despite "proof" of its dangers to human life. In education, conventional wisdom may have done away with the cat-o'nine-tails and most other crude forms of physical punishment, but it clings obstinately to a multitude of corollaries of "spare the rod and spoil the child." These two fundamental issues --- the uncertainty of scientific knowledge itself and the "non-rational" origins of human behavior --- cloud the distinction between our categories of "scientific" and "non-scientific" knowledge. There is a common sense vigor to the distinction between them when referring to the physical sciences --- the solid wood table top recognized by non-scientific knowledge is clearly different from the collection of molecules divided into atoms and so on that scientific knowledge has given us. But in the field of social sciences the clear division fades and is replaced by a shifting, easily penetrated barrier. It is difficult to adduce a difference in "kind" of knowledge which, in turn, would allow us to show that there is a fundamental difference in the process by which each is created.

The brunt of our last argument has been to efface the difference in "kind" assumed to separate the different roles of persons in the chain from research to utilization. In fact, the arguments have been brought forward to show that the existence of such a presumed linear sequence is the exception rather than the rule. If one accepts that the different agents referred to --- researchers, developers, etc. --- may have differing goals (related in some fashion to their different individual knowledge bases), it follows that the sequence by which "knowledge is translated into practice" occurs at each point along the spectrum and can occur without reference to any other point in the lines: researchers can pursue their interests without reference to applications, developers can develop products without an application, linkage mechanisms can deliver information which is not used, practitioners can ignore the mandates of science and instead imitate traditional methods of teaching, etc. Conversely, links along the chain can occur fortuitously or, good management practices (perhaps called "R&D") can raise their probability of occurrence well above the threshold of pure chance.

Rather than visualize "R&D" as a linear sequence of translation of scientific knowledge into practice, we can use the agent-information interaction sequence to visualize something on a more molecular level: An infinity of agent-information interactions occurring continuously along a spectrum which, at the research end, has very few molecules and, at the practice end, has a great bulk of molecules. Unlike the world of gaseous diffusion, human society is not dependent upon random encounters. The thing called "R&D" can be equated neither with random diffusion nor with some simple mechanistic process by which an idea issuing from research is shot like an arrow in the direction of "practice," where it makes an "impact," but rather with a sort of catalyst which, at any point in the chain, facilitates the agent-information interaction process. This may mean, in concrete terms, improving the "atmosphere" in which pure research occurs or facilitating rational problem-solving in a junior high school; if knowledge, whether "scientific" or "non-scientific", is that which resists the test of practice and application, then this facilitating function will, by definition, increase the speed with which the scientifically verified "idea" will reach practice. Those with a taste for viewing the world as an entity to be managed will derive an operational definition of R&D as the technique of managing the information-agent interaction; for those who think that "structure" or "establishment" is the major obstacle to human progress, this view can provide a charter for liberation, to "free" the molecules --- the human beings --- to interact and develop their experience base; those who believe in the power of ideas will see this as a simplistic view of the way in which an idea can transform society.

There is no way of saying if one is right, or all are. For this analysis of R&D has led us to equate it with an objective, not with a definable thing or a specific technique, and certainly not the specific methodology which gave us the Apollo moonshots or the Mustang II. The objective is to facilitate R&D, spelled out as research of knowledge and development of whatever it is that human beings, in the light of their knowledge, fix as their goal. The definition is thus recursive: The objective is to use search for knowledge as a means of attaining objectives defined in terms of the knowledge that one is continually searching to add to. One feels that, somehow, that is the way it should be defined.

For those who seek to formalize models, the following notes indicate the main elements to be included in a formal statement of the agent-information interaction model:

1. $A_{1,2..n}$ - Agents, that is humans either as individuals or collectivities
2. K_s - The societal knowledge base
3. K_{A_n} - The portion of the societal knowledge base accessible at a given time to a given agent (A_n)
4. y - Knowledge "loss" such that, between times t_1 and t_2:

$$K_s \cdot y_{t1,+t2} = K_{A_n}$$

- y analyzes into two components:

  y_i - an intrinsic loss deriving from the nature of the way the knowledge is stored, an entropy familiar to the analyst of information systems (including in the case of the societal knowledge base outright disappearance of information resulting from the physical disappearance of the storage medium)

  y_n - a loss deriving from the particular characteristics of a given agent A_n involved in accessing the societal knowledge base; that is, we are dealing with an index of the "inefficiency" of the agent (or the means at his disposal) as an access mechanism.

  y_i and y_n are not necessarily independent.

5. O_K - Added organization of knowledge such that, between time periods t_1 and t_2 (ignoring loss $y_{t_1,\, t_2}$):

$$K_s\ (t_2) = K_{s\ (t_1)} * O_K\ (t_1,\ t_2)$$

where the specific content of the operator * depends upon the nature of O_K: logical union for the simple addition of new data would be rare, the most common operation involving a complex set of specifications of relations between previous knowledge and the "new" knowledge, some of them implying the negation or disappearance of previous knowledge.

- It follows that, introducing loss:

$$K_{A_{n\ (t_2)}} = K_{s\ (t_2)} \cdot y_{t_1,t_2}$$

6. The societal knowledge base is necessarily defined in terms of a given society. There are two possible procedures for defining this:

6a. The "society" may be defined as a set of agents $\{A_r, A_s \ldots . A_2\}$.

These agents could then be viewed as sharing exactly equivalent status as regards their contributions to the knowledge base such that K_3 for the given society would be the logical union of all accessible knowledge for the set of agents. Or, without equivalent status, each could contribute some proportion of its accessible knowledge, modified by a loss factor: $K_{A_n} \cdot y$

6b. Conversely, a "society" may be defined in terms of the extent to which knowledge is shared between agents. One might visualize a universe of agents as nodes in a communication network. Taking any one node as a base, one can move "outward" in the network until one reaches the outermost nodes from which additions to the base of knowledge accessible to the first node cease to be possible within a defined, finite time span. All nodes capable of making contributions to that central node's base of accessible knowledge constitute the "society" of that node. The transmission along the network would result in information losses of the type defined above (y_i).

(This definition of a "society" is analogous to the concept of a gene pool operating for a given species or the molecular theory of natural language development and diversification over a large geographic area. It does not imply, however, that communication of knowledge occurs solely through interpersonal contact between agents; such communication in the network could be mediated via other mechanisms).

7. The relationship between added organization of knowledge and the concept of information content elaborated in modern communications theory deserves to be explored. The fundamental definition of information revolves around the concept of novelty, a message having a predictable content would lack novelty and thereby "information content." In terms of a knowledge base conceived of as a set of interrelated, partially consistent hypotheses, an entirely contradictory hypotheses refuting the basis of most of the existing hypotheses (such as the concept that time if "relative" in the physical world) would appear to have a high novelty value, but as in the case of a "wild idea" would not necessarily be an addition to the knowledge base. In this light, added organization of knowledge would appear to involve establishment of relationships between previous knowledge and new information; the importance of the addition would presumably be proportionate to the degree to which the new information appeared unpredictable on the basis of previous knowledge. In other words, it would be directly proportional to the information content of the integrated information.

3. Secondary infrastructure
    a. Specialized personnel training system (highly qualified research, development, dissemination personnel)
        1) Institutional base and programs
        2) Personnel
    b. Development of specialized equipment for use in R&D
4. Regulators: trends in policy and funding (mainly Federal), implications
    a. Institutions
        1) Problems of continuity for institutional development
        2) Creation of NIE and its implications
    b. Personnel
        1) Career continuity and recruitment
        2) Shortages and oversupplies, sectoral distortions

D. Operations

1. Introduction
    a. Types of indicators: activity levels for functions (R,D,D, &c.), products and outcomes for throughput
    b. Problem of discontinuity between different portions of system (production/creation not necessarily related to distribution/exchange, which does not necessarily result in utilization &c.)
    c. Leading to grouping of indicators separately
2. Intermediate indicators of system operations
    a. Creation/production } (function activity level
    b. Distribution/exchange) x (product & outcome throughput
    c. Utilization)
        1) Problems of measuring impact and utilization
            a) Problems of measuring impact of one factor among many
            b) Question of relative size of investment in R&D and planned innovation compared to size of total operating system
            c) Need for data on the operating system as a framework for understanding utilization data
        2) The public for educational research, development, and planned innovation
        3) Trends of educational change
        4) Indicators for the operating educational system
        5) Indicators of R&D utilization
        6) The unresolved issues:
            a) Quality
            b) Productivity
            c) Separation of system impact from product utilization

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      4) Indicators for the operating educational system
      5) Indicators of R&D utilization
      6) The unresolved issues:
         a) Quality
         b) Productivity
         c) Separation of system impact from product utilization

E. Regulators (for throughput)

- 1. Introduction
  - a. Regulators affecting operations (not infrastructure) included here
  - b. Generality of concept of regulators, limited scope of this summary
- 2. Market forces and governmental intervention
  - a. Concepts of supply and demand, imperfect market, regulated market, market intervention and subsidization
  - b. Direct intervention: sponsorship and subsidization of activity
    - 1) The Federal role
      - a) Decision-making structures and processes of major federal agencies
      - b) Description of major sponsors and programs
    - 2) Other sponsors (foundations)
  - c. Indirect intervention: the manipulation of incentives
    - 1) Creation and production: direct support
    - 2) Distribution and exchange: copyright, public carriers (ETV) regulation, etc.
    - 3) Utilization: subsidization, advocacy
- 3. The legal and administrative framework
  - a. Statutory law, regulations, ordinances
    - 1) Federal: e.g., forms clearance, human subjects at risk
    - 2) State and local: e.g., access to schools for R&D purposes
  - b. Systems and policies of public education agencies [Special reference to: planning for change, adapting and implementing R&D outputs, participation patterns in process of planning, deciding and implementing changes.]
  - c. Management techniques for R&D, planned innovation
    - 1) Major funding sources (particularly NIE)
    - 2) Program and project management (selected institutions)
- 4. The climate of change
  - a. The public: trends and issues of public opinion on education
  - b. The professional: evolving roles, attitudes and status of the teaching profession
  - c. The youth agenda: needs or demands, child or consumer?
  - d. The future of education: projections, predictions, utopias

F. Information on the system

- 1. Selected references and sources of data
- 2. Research on the R&D system
  - a. Models and proposals
  - b. Major research in progress